ROHDE & SCHWARZ
MÜNCHEN

Servicing Manual

CONTROL UNIT 239.1000

of Radio-Set Test Assembly
SMPU 239.0010

MP MASTER
MA23829

R 31503 - 1

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Table 5-1 Table for function control Y3
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Compilation Schedule (Zusammenstell-Vorschrift)

Note

The present Servicing Manual covers the versions 239.1000.51 and 239.1000.52 of the SMPU Control Unit. This manual also applies to the Control Unit of the Receiver Test Assembly (versions 239.1000.53 and 239.1000.54) except that some of the subassemblies are not contained in these versions. The equipment of the respective SMPU version can be seen in circuit diagram 239.1000 S Bl. 4.

3. Maintenance

3.1 Required Measuring Instruments and Accessories

No.	○ Equipment, required data ● Recommended R&S instrument	Type	Order No.	Use in section
1	○ UHF millivoltmeter			3.2.8
	● RF-DC Millivoltmeter 1 kHz - 1.6 GHz AC: 2 mV - 10 (300) V DC: 1 mV - 1000 V	URV	100.0130.02	
2	○ Frequency counter up to 500 MHz			3.2.1
	● Electronic Counter	FET 2	-	
	Basic Unit		100.6039.02	
	10 - 800 MHz Plug-in		100.6080.02	
	● Frequency Controller and Counter Adapter	SMDA-Z SMDA-Z	100.4542.03 100.8131.02	
	● Frequency Counter of SMDU, see item 11			
3	○ Oscilloscope Bandwidth 0 - 90 MHz			3.2.3
	● Oscilloscope of Tektronix Series 7000			
4	○ Power meter 10 kHz - 500 MHz; 50 Ω			3.2.2 3.2.5 3.2.6 3.2.7
	● Microwave Power Meter and	NRS	100.2433.92	
	50-Ω Probe 0 - 15 GHz, 0.1 - 330 mW		100.2440.50	
5	○ Signal generator 50 kHz - 550 MHz, 3 V			3.2.1 3.2.2 3.2.6
	● Power Signal Generator 25 - 1000 MHz, 10 V into 50 Ω	SMLU	200.1009	
6	○ AF generator 50 Hz - 100 kHz			3.2.1 3.2.3
	● see item 11			
7	○ AF distortion meter			3.2.3
	● Wave Analyzer 5 Hz - 20 kHz Bandwidth 4/20/120 Hz Voltage range 0.1 µV - 30 V Dynamic range 100 dB Sweeper	FAT 3	100.8702.92	
8	○ Ohmmeter			3.2.8
	● Multimeter VOLTAN 0 - 100 kHz	UVV	110.4716.02	

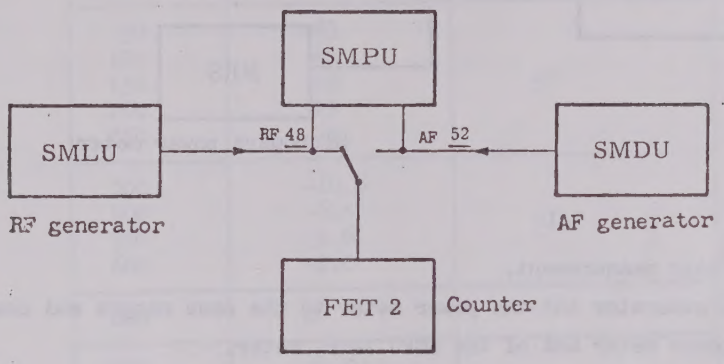
No.	○ Equipment, required data ● Recommended R&S instrument	Type	Order No.	Use in section
9	○ Digital voltmeter ● Digital Multimeter 40 Hz - 20 kHz, 5 digits	UGD 51	234.05.....	3.2.8 3.2.17
10	○ AF millivoltmeter ● AF Millivoltmeter 10 Hz - 1 MHz, 0.1 mV - 300 V, Z_{in} = 1 MΩ shunted by 30 pF	UVN	100.0160.02	3.2.3
11	○ FM signal generator ● Signal Generator (universal model) 15 Hz - 525 MHz	SMDU	249.3011.04	3.2.4
12	○ Modulation meter e.g. AFM 2 or unit made by Radio meter			3.2.4 3.2.5 3.2.18
13	○ Squarewave generator TTL level ● Precision LF Generator 0.01 Hz - 120 kHz sinewave 0.01 Hz - 1.2 MHz square- wave (TTL)	SSN	204.8014	3.2.9
14	○ Talker and listener for interface in line with IEC ● Tektronix Desk-top Calculator TEK 31 and Interface	SMPU-Z2	240.3902.02	3.2.9 3.2.10 3.2.17
15	○ Test receiver ● VHF-UHF Test Receiver Basic Unit Plug-ins RF Plug-in I (25 - 230 MHz) RF Plug-in II (160 - 470 MHz)	ESU	 100.1143.02 100.1189.02 100.1195.02	3.2.20
16	○ Attenuator set 0 - 140 dB ● Programmable Attenuator Set	DPVP	214.8017.52	3.2.20

3.2 Checking the Specified Performance

3.2.1 Checking the Frequency Meter

Accuracy check:

Test setup:



Measurement in the RF range 50 kHz - 400 MHz

Set SMPU for transmitter measurement.

Set RF generator to 50/100/300 kHz/1/3/10/100/400 MHz with output levels of 10 mV and 3 V.

Compare SMPU reading with reading of external counter.

Measurement in the RF range 400 MHz - 520 MHz

Set SMPU for transmitter measurement.

Set RF generator to 400/450/500/520 MHz with output levels of 100 mV and 3 V.

Compare SMPU reading with reading of external counter.

Measurement in the AF range

Set SMPU for receiver measurement and depress MOD. GENERATOR EXT. button. Set AF level meter for 30 mV f.s.d.

Set AF generator to 50/100/300 Hz/1/3/10/30/100 kHz with an output level of 10 mV.

Compare SMPU reading with reading of external counter.

Sensitivity check

Test setup: same as for accuracy check.

Measurement:

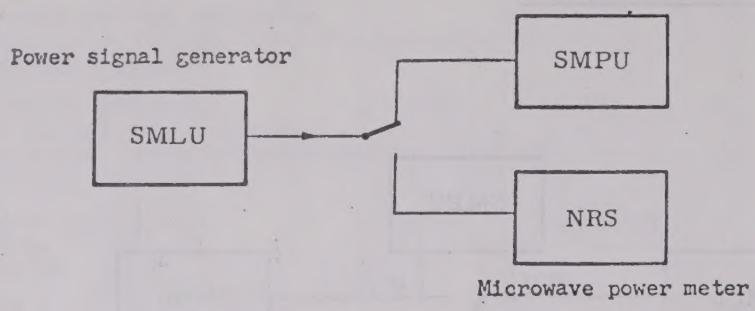
Set SMPU for transmitter measurement.

Set RF generator for 10 mV output level at 50 MHz and 400 MHz and to 50 mV at 500 MHz.

The reading of the external counter must agree with that of the SMPU frequency readout.

3.2.2 Checking the RF Level Meter

Test setup:



Measurement:

Set SMPU for transmitter measurement.

Set the power signal generator and the power meter to the same ranges and compare the indications of the power meter and of the SMPU level meter.

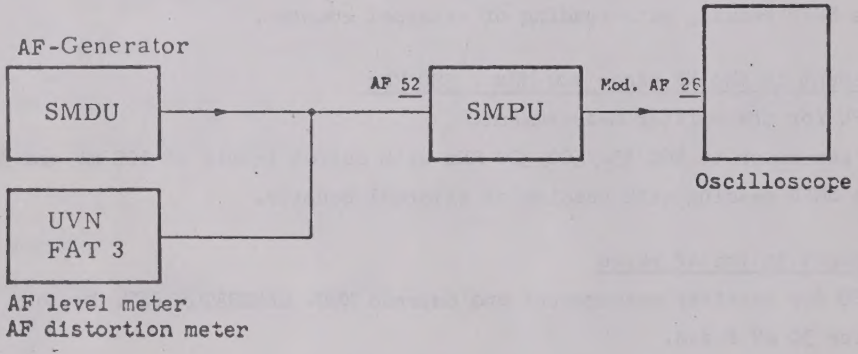
Take measurements at various frequencies and levels.

Error limits of the RF level meter ±(6% of rdg. +1.5% of f.s.d.).

If necessary adjust or locate the fault.

3.2.3 Checking the AF Level Meter

Test setup:



AF level measurement

Set SMPU for receiver measurement.

Set AF generator at 1 kHz to 3/10/30/100/300 mV/1/3/10 V and check level with external AF level meter.

Select appropriate AF range on SMPU and check meter deflection; error should be < ±(2.5% of rdg. + 1.5% of f.s.d.).

Distortion measurement

Set SMPU for receiver measurement.

Set AF generator, first at 300 Hz ±1%, then at 1 kHz ±1%, to 100/300 mV/1/3/10 V and read distortion factor on external distortion meter.

Select the distortion button associated with the frequency. Read distortion factor on the digital display and compare with the indication of the external distortion meter; error < ±(2% of rdg. + 1 digit).

Weighting filter complying with CCITT standard

Set SMPU for receiver measurement and switch CCITT filter on.

Set AF generator to 0 dBm and check the frequency response on the meter according to the following table:

Frequency Hz	Attenuation dB	Tolerance dB
50 100 150 200 250	-63 -41 -29 -21 -15	±2
300 400 500 600	-10.6 -6.4 -3.6 -2.0	±1
800	0	0
1000 1200 1250 1500 2000 2500 3000	+1.0 0 -0.2 -1.3 -3.0 -4.2 -5.6	±1
3500	-8.5	±2
4000 4500 5000	-15 -25 -36	±3

MOD. AF output

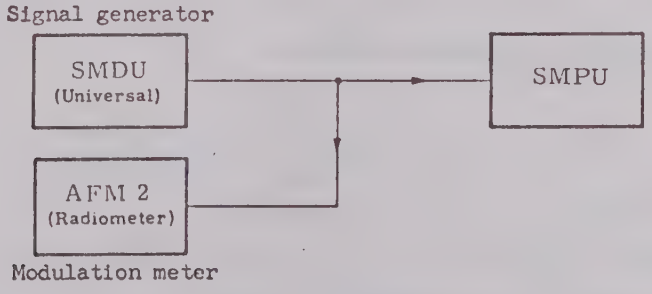
Set SMPU for receiver measurement.

Set AF generator for 1 V at 0.05 - 20 kHz.

Check AF voltage of 1 V at MOD. AF output of SMPU with an oscilloscope.

3.2.4 Checking the Deviation Meter

Test setup:



Measurement of wanted modulation with FM

Set SMPU for transmitter measurement and press MOD. MEAS. FM button.
Modulate signal generator at 100 MHz with 1 kHz modulation frequency and 5 kHz frequency deviation. Select 5-kHz range of SMPU modulation meter and compare meter readings.
The SMPU should read f.s.d., error < ±(1.5% of rdg. +1.5 % of f.s.d.).

Measurement of wanted modulation with φ M

The procedure is the same as for the measurement with FM, except that the signal generator is modulated with 5 rad phase deviation and the MOD. MEAS. M button is depressed.

Measurement of inherent spurious modulation

Do not apply any RF signal, switch CCITT filter off. Set SMPU for transmitter measurement and depress MOD. MEAS. FM button. Depress range button 5 kHz and MOD. GEN. OFF button, meaning that the 50 Hz deviation measurement range is selected. An inherent spurious deviation of about 12 Hz is permissible.

IF identification

Set SMPU for transmitter measurement and depress MOD. MEAS. FM button. Modulate signal generator (e.g. 100 MHz) with 1 kHz modulation frequency and 5 kHz frequency deviation.
If no RF signal is present at 48 or 49 , the ALARM lamp must light and the pointer of meter 14 should be at 0.
When the signal generator is connected to the RF socket 48 or 49 , the ALARM lamp must go out after about 1.5 sec and the frequency deviation should be indicated as set. Vary the signal-generator frequency; the ALARM lamp must then light for 1.5 sec. When the lamp has gone out, the set frequency deviation must be indicated.

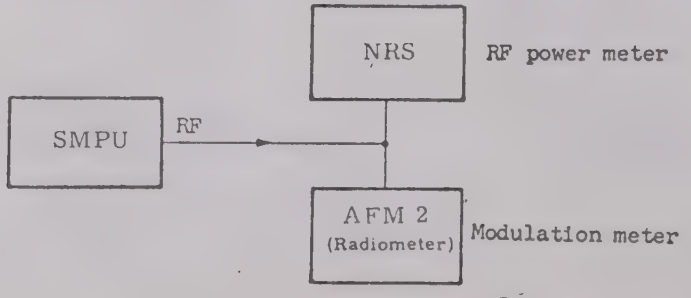
Deemphasis

Set SMPU for transmitter measurement and depress MOD. MEAS. φ M button. Modulate signal generator at 100 MHz with 5 rad phase deviation. Vary the modulation frequency and check the frequency response according to the following table:

Mod. frequency	Pointer deflection
1 kHz	f.s.d.
2 kHz	1/2 f.s.d.
3 kHz	1/3 f.s.d.

3.2.5 Checking the ALC and Amplitude Modulation

Test setup



ALC

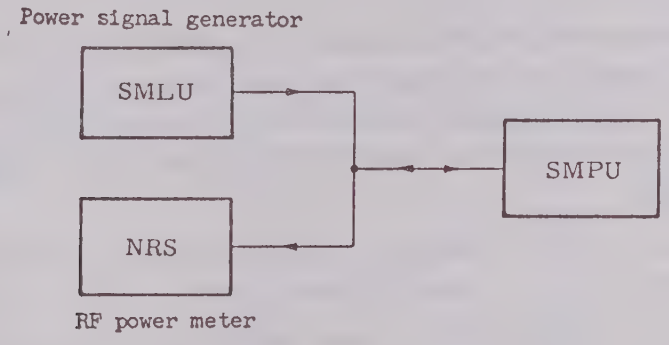
Set SMPU for receiver measurement and select RF level 0 dBV.
Vary frequency from 0.4 to 500 MHz; RF output power must be 5 mW ±1 dB.

Amplitude modulation

Set SMPU for receiver measurement and amplitude-modulate the signal at any RF level. Set 40% and 90% modulation depth at various frequencies and check with external modulation meter. The error of modulation-depth setting should be < ±3% at a modulation frequency of 1 kHz.

3.2.6 Checking the RF Switching Board

Test setup:



SMPU switched off

Apply to RF socket 49 (Fig. 2-1) a DC voltage of 1 V for the 25-W model or of 2 V for the 50-W model, while the SMPU is switched off.
Connect voltmeter to 50 ANALYS.; the DC voltage fed in must be attenuated by 26 dB (25-W model) or 29 dB (50-W model).

Output RF2 74

Set SMPU for analyzer measurement, 100 MHz, 0 dBV (RF LEVEL on). Connect RF power meter to RF2 socket 74 . The power meter must read 5 mW.

Receiver test

Set SMPU for receiver measurement, 100 MHz, 0 dBV. Connect RF power meter to RF socket 49. The power meter must read 5 mW.

Duplexer test

Set SMPU for duplexer test, 100 MHz, 0 dBV. Connect RF power meter to RF socket 49 . The power meter must read 0.5 mW.

3.2.7 Checking the RF Overload Protection

Test setup as under 3.3.6, apply signal to RF socket 49 . Set signal generator at 100 MHz to 50 mW by referring to the indication of the RF power meter.

Set SMPU for receiver measurement, -140 dB. Increase level of signal generator. The RF overload protection must respond at about 300 mW and the RF switching board switches over. The range indication of the power meter in the SMPU is switched on and the meter indicates the corresponding power.

3.2.8 Checking the Relay Board

Check the functioning of the control relays and of their driving signals with an ohmmeter connected to the CONTR. socket. The contacts are floating. Contact C is shorted to A in transmitter tests, C to H in receiver tests. When the MOD.-GENERATOR EXT. button is depressed, B is shorted to C. When a squelch program is selected or VAR. DC depressed, contact F is shorted to J.

To check the RF relays and their driving signals, connect an RF millivoltmeter (e.g. URV) to RF output 49 to monitor the RF output level. When switching from receiver test to duplexer test, the RF level decreases by 20 dB. When analyzer operation is selected or when the RF level is switched on, the voltage of the RF generator is applied to the RF2 socket 75 on the rear.

When button AM EXT. or FM EXT. is depressed, it must be possible to modulate the RF generator via the external modulation inputs 27 and 28 .

When the FM input is DC-coupled (FM-DC), it must be possible to vary the frequency of the RF generator as a function of DC voltage and frequency deviation.

By depressing the button VAR. DC, a well-defined DC voltage is connected to the AF attenuator of the AM modulator. (In this case the RF generator can be externally amplitude-modulated via the FM input 28). The RF level then depends directly on the modulation depth (100% = normal level).

3.2.9 Checking the IEC Interface

The measurement is taken at the DATA I/O connector 77 .
For the static check of the control lines RFD (ready for data), DAC (data accepted) and DAV (data valid), the address line ATN (attention) is taken to 0 V and the clock line DAV is switched.

The following truth table must be obtained:

DAV	RFD	DAC
H	H	L
L	L	H

The dynamic test is also carried out at ATN = 0 V. Connect a squarewave generator or a talker to the DAV input. Check the RFD and DAC lines with a dual-beam oscilloscope. DAC must go to logic H about 200 ns after the falling edge of the DAV signal. The RFD signal is displaced about 40 ns with respect to the DAV input signal.

Then check addressing and handshake simultaneously. Two LED's are provided in the set to check the address setting. The listening mode (reception) is recognized by the DAC

output being at L level. With the other addresses set (talk, untalk, unlisten), RFD and DAC are at H level.

Check the data entry when the receive address is set. The data entry function is recognized by means of the driven displays and lamps. In case of an error the respective program command is to be executed manually. The data entered being binary-coded, it is sufficient to enter the level ranges 10 mV (!), 30 mV (") and 100 mV ( ) and the digits 1, 2, 4, 8.

To check the programming of the commands of columns 4 and 5 of the ASCII table and the driving of the function control, it is sufficient to enter the signals of the following table successively. The last ASCII signals (A W) cause the counted RF frequency to be output. Following the entry of these signals, the SMPU must be switched to "talker". 8 figures and the clear signal CRT are output.

ASCII signal	Explanation	Button (Fig. 2-1)
K]	FM - DC	32
M]	FM - EXT	31
N]	OFF	33
A [	MODULATION ON	42
1	Figure	22
2	Figure	22
.		22
4	Figure	22
A ↑	FM entry	FM 17
A W	RF readout	

If the IFC (interface clear) line is taken to 0 V, RFD, DAC and DAV must go to logic H. The addresses and BUSY indication are thereby erased.

3.2.10 Checking the A/D Converter

This check is carried out manually and by program. The entered digits 1, 2, 4 and 8 must appear on the SMPU display after the entry instruction has been given (by pressing the corresponding button or by the program).

It must be possible to change the measurement ranges of the AF level meter; the range selected must be displayed by the buttons 6 .

The functionning of the A/D converter and the switching of the AF level ranges can be checked simultaneously if an AF signal of 1 kHz is applied to the AF socket 52 and the SMPU is set for distortion measurement. The level-meter range is then selected by the micro-computer such that the pointer deflection is between 30% and 100% of f.s.d. The measurement range must be switched over automatically according to the AF input level.

In programmed operation, the ASCII signals for outputting the AF level, RF level and external DC voltage must be entered. The output figures (0 to 1023) must be proportional to the entered signal. The AF-level and RF-level output must contain as the last digit the code figure of the selected measuring range.

If DAV is at L level or if the BUSY lamp lights, manual setting and programmed data entry are inhibited.

3.2.11 Checking the Data Entry

The PROG.-COMB.-MAN. switch must inhibit the manual entry in position PROG. and the programmed entry in position MAN. When the switch is at COMB., both modes must be possible.

Check with manual data entry whether the corresponding lamps are set or reset upon depressing a button. To exclude errors in manual data entry, the data can be entered additionally via the programming input DATA I/O while the illuminated buttons are observed.

In addition to the data entry for the function control, check the entry of figures by the pushbuttons 22 . It is sufficient to enter the digits 1/2/4/8. Using one of the entry buttons (16 , 17 , 18), check whether the digits are stored in the micro computer and then in a display register so that they appear in the corresponding digital display.

When a VAR button is depressed, it must light up. Checking of the 1-kHz, 100-kHz and AF variation is sufficient since it covers the check of the three variation address lines. When the VARIATION knob is turned clockwise, the quantity concerned increases, with counterclockwise rotation it decreases.

Check the entry and display of the AF level ranges in the receiver test mode; checking of the ranges 10/30/300 mV is sufficient.

The modulation measurement ranges and the functioning of the x0.01 button are checked in the transmitter test mode. The measurement range must agree with the button depressed. Switching on and off of the x0.01 button must be possible.

The buttons DISTORTION 1 kHz and 300 Hz start a distortion measuring routine in the micro computer of the SMPU. The button depressed must light up periodically and the character C must appear in the RESULT display at the extreme right. The distortion measuring routine must be erasable with the DISTORTION OFF button.

3.2.12 Checking the Keyboard Entry

Entry on keyboard 22	Storing with button	Display and functions
Button CLEAR 24	16 , 17 , 18 , 21	0 on 1 , 2, 3 , 4 . The automatic routines except distortion and S/N measurement must be interrupted immediately. The BUSY and OVERFLOW lamp go out. (Should OVERFLOW not be erased, either RF $\geq$ 500 MHz or level $\leq$ -142 dB).

Entry on keyboard 22	Storing with button	Display and functions
Figure 1	RF 16	1 MHz on display 1 if data bus 2^0 intact
Figure 2	RF 16	2 MHz on display 1 if data bus 2^1 intact
Figure 4	RF 16	4 MHz on display 1 if data bus 2^2 intact
Figure 8	RF 16	8 MHz on display 1 if data bus 2^3 intact
Figure 01	RF 16	1 MHz on display 1
Figure 001	RF 16	1 MHz on display 1
Figure 1.	RF 16	1 MHz on display 1
Figure 1.0	RF 16	1 MHz on display 1
Figure 0.123	RF 16	000.12300 MHz on display 1
Figure .123	RF 16	000.12300 MHz on display 1
Figure 123.45678	RF 16	123.45678 MHz on display 1
Figure 123.456789	RF 16	123.45678 MHz on display 1 , OVERFLOW lights
Figure 1234.56789	RF 16	No effect on display, OVERFLOW lights
Figure 12.345	AF 16	12.3 kHz on display 2
Figure 1.2345	AF 16	1.23 kHz on display 2
Figure .12345	AF 16	.123 kHz on display 2
Figure .012345	AF 16	0.123 kHz on display 2
Figure .0012	AF 16	No effect on display 2 , OVERFLOW lights
Figure 123.45	AF 16	No effect on display 2 , OVERFLOW lights
Figure 1	AM 17	1% on display 3
Figure 1.23	AM 17	1% on display 3
Figure 12	AM 17	12% on display 3
Figure 12.3	AM 17	12% on display 3
Figure 123	AM 17	No effect on display 3 , OVERFLOW lights
Figure 1	FM or φ M 17	1 kHz or 1 rad on display 3
Figure 1.	FM or φ M 17	1 kHz or 1 rad on display 3
Figure 12	FM or φ M 17	12 kHz or 12 rad on display 3
Figure 12.	FM or φ M 17	12 kHz or 12 rad on display 3
Figure 12.34	FM or φ M 17	12.3 kHz or 12.3 rad on display 3
Figure 123	FM or φ M 17	No effect on display 3 , OVERFLOW lights

Entry on keyboard 22	Storing with button	Display and functions
Figure 1	AF 18	1 V on display 3
Figure 1.	AF 18	1 V on display 3
Figure 1.23	AF 18	1.23 V on display 3
Figure .12	AF 18	0.12 V on display 3
Figure 0.12	AF 18	0.12 V on display 3
Figure 12.3	AF 18	No effect on display 3 , OVERFLOW lights
Figure 1	RF 18	-1 dB on display 4
Figure 1.	RF 18	-1 dB on display 4
Figure 12	RF 18	-12 dB on display 4
Figure 12.	RF 18	-12 dB on display 4
Figure 123	RF 18	-123 dB on display 4
Figure 123.	RF 18	-123 dB on display 4
Figure 1234	RF 18	No effect on display 4 , OVERFLOW lights
Figure 142	RF 18	-142 dB on display 4 , OVERFLOW lights and cannot be erased by CLEAR 24 but only by changing to -141 dB or by entering a permissible value.

3.2.13 Checking the Variation of the Data Set

Knob 25 : clockwise rotation = positive variation,
counterclockwise rotation = negative variation.

Set RF frequency to any value and successively adjust the 100-kHz variation (15 left), 1-kHz variation (15 centre) and 10-Hz variation (15 right). Turn knob 25 clockwise (positive) and counterclockwise (negative) for each of the three adjustments and check that the transfers are correct.
Enter 0 MHz, negative variation up to 0 MHz (electronic stop)
Enter 999.99999 MHz, positive variation up to 0 MHz (upper limit).

AF frequency variation, enabled with l.h. button 5 .

Enter 99.9 kHz, positive variation up to .0100 kHz (upper limit)
Enter 9.99 kHz, positive variation up to 10.0 kHz (upper limit)
Enter .999 kHz, positive variation up to 1.00 kHz (upper limit)
Enter .0999 kHz, positive variation up to .100 kHz (upper limit)

Enter .0100 kHz, negative variation up to .0100 kHz (electronic stop)
Enter .100 kHz, negative variation up to .0999 kHz (electronic stop)
Enter 1.00 kHz, negative variation up to .999 kHz (electronic stop)
Enter 10.0 kHz, negative variation up to 9.99 kHz (electronic stop)

AM mod. variation, enabled with 36 AM and 5 (centre).
Adjust to any value and check positive and negative variation:
Enter 99, positive variation up to 00 (upper limit)
Enter 00, negative variation up to 00 (electronic stop)

φ M mod. variation, enabled with φ M 36 and 5 (centre).
Adjust to any value and check positive and negative variation:
Enter 99.9, positive variation up to 00 (upper limit)
Enter 00.0, negative variation up to 00 (electronic stop)

FM mod. variation, enabled with FM 36 and 5 (centre).
Adjust to any value and check positive and negative variation:
Enter 99.9, positive variation up to 00 (upper limit)
Enter 00 , negative variation up to 00 (electronic stop)

AF level variation, enabled with 5 (centre) in transmitter test mode.
Adjust to any value and check positive and negative variation:
Enter 9.99, positive variation up to 00 (upper limit)
Enter 0 , negative variation up to 00 (electronic stop)

RF level variation, enabled with 5 (right)
Adjust to any value and check positive and negative variation:
Enter 141, positive variation up to 142 (OVERFLOW)
Enter 000, negative variation up to 000 (electronic stop)
Enter 142, negative variation up to 141, OVERFLOW erased

Frequency variation in δ f steps
Enter figure 1 and store with 21 . The increased or decreased RF is displayed on 1 only after one of buttons 23 has been depressed. Check also the display of the figures 1./123456./.12. When the figure 1234567 is entered, no display should appear and OVERFLOW must light.

3.2.14 Checking the Regeneration Programs

In order to check that the entered data are stored in the SMPU or displayed, values + 0 must be present at all entries.
To check for correct regeneration of the modulation values, switch 37 to FM, φ M and AM.
By changing from transmitter test 68 to receiver test 57 , check that the values displayed on 1 , 2 , 3 and 4 are correctly stored and regenerated.

3.2.15 Checking the Counter and Deviation Meter

Press button 58 XMITTER and apply an RF and an AF signal. Vary both frequencies, observing the counter readings. Switch on the deviation meter with 36 and the RF level with 43 . Change the deviation indication over with 40 ; the frequency must increase 100 kHz with positive deviation and decrease 100 kHz with negative deviation.

3.2.16 Checking the Automatic Programs

The program execution can be checked by observing the illuminated buttons and digital displays. Different programs are started with the buttons 10 , 45 , 46 , 54 and 55 .

Bandwidth measurement (55): Setting attenuator to 141 dB, outputting centre frequency of RF channel. Automatic range selection, switching to 10 dB more sensitive range, decreasing attenuation of attenuator until 6-dB point is reached; decreasing attenuation of attenuator by 6 dB. Frequency variation from centre frequency towards higher values with positive deviation or towards lower values with negative deviation. Frequency is varied first in kHz steps then in 100-Hz steps until 6-dB point is reached. The result appears in kHz on the RESULT display.

Sensitivity measurement (54): Setting attenuator to 141 dB, outputting centre frequency of RF channel, modulation off (or filter on with SINAD), switching internal level range to 12 dB or 20 dB higher sensitivity, switching attenuator in 5-dB steps for coarse approximation, then variation in 1-dB steps until reference value is reached.

Squelch measurement (46): Setting attenuator to 141 dB, setting deviation, automatic range selection, switching range to 20 dB less sensitivity, AM to 95%, reducing attenuator setting in 1-dB steps until RF level high enough for through-connection of AF signal.

SQUELCH ↑	SQUELCH ↓
Setting electronic attenuation standard to 0% (i.e. no RF level), waiting time 1.2 s to make sure that squelch switches; setting electronic attenuation standard to 70%, increasing in 1% steps until RF level is sufficient to connect AF level through. When switch-on point is reached, % is converted into dB and read out on RESULT display	Decreasing electronic attenuation standard in 1% steps until RF level is so low that squelch cuts AF signal off. When switch-off point is reached, % is converted into dB and read out on RESULT display.

Distortion measurement (10): When distortion measurement is ON, the 1-kHz or 300-Hz filter is cut off and automatic range selection is performed. The signal value is stored. Then the corresponding filter is cut in and the harmonic content is measured. The micro computer calculates the result in % from the two values and conveys it to the RESULT display. The program runs continuously and can only be stopped by pressing button OFF 10 .

S/N or SINAD at any RF levels (45): The program runs as that for distortion measurement, except that the output is in dB instead of %.

Check that all functions of distortion measurement and SNR measurement can be performed, for example that data inputting or selection of another automatic program is possible during distortion measurement. The distortion meter must continue to run automatically at the end of a program (BUSY lamp goes out); exception: squelch measurement.

3.2.17 Checking the Digital Displays

The checks should be made with manual and with programmed operation, by entering the figures 1/2/4/8 into each decimal place. The LED's of the displays are thereby checked at the same time.

In the 8-digit RF frequency display 1 the decimal point must light up after the third digit. The internally stored RF is displayed in receiver tests and the externally measured RF in transmitter tests.

The internal AF is entered in three digits. The three digits appear in the extreme right places of the AF display 2 . The decimal point shifts according to the range. In the range 0 (10.0 to 99.9 Hz) a zero is entered in the second place. To check the digital display and range identification simultaneously, enter the following frequencies:

Entry and display	Range	Frequency range
.0111 kHz	0	10.0 - 99.9 Hz
.222 kHz	1	100 - 999 Hz
4.44 kHz	2	1 - 9.99 kHz
88.8 kHz	3	10 - 99.9 kHz

Switchover of the indicators MOD. GEN. and RESULT must be possible with the MOD. GENERATOR INT and EXT buttons 38 .

When the indicator RESULT lights, all five digits and the decimal point after the second digit must light.

The hexadecimal display of modulation is reset when the internal modulation is cut off. The display of the physical unit (V, kHz, rad, %) must remain.

AF level, frequency deviation and phase deviation are displayed in three digits and modulation depth in two digits on display 3 . The appropriate physical unit must light up. The decimal point is after the first digit when AF level is displayed and after the second digit when frequency deviation or phase deviation is displayed.

The RF level of the SMPU is displayed in 3 digits on 4 . The display can be switched on and off with the RF LEVEL button 43 .

3.2.18 Checking the AF Generator

Presettings: Set SMPU for receiver test or duplexer test and to CHECK. Connect 53 (Fig. 2-1) to 52 with a BNC cable. Enter an AF level of 1 V and select the 1-V range of the level meter.

Frequency check:

Enter the desired AF. Display 2 indicates the frequency of the AF generator; a departure of ±2% from the input frequency is permissible.

Output-voltage check:

A deviation of the level indication 14 by ±2% (up to 20 kHz) from the input level is permissible. The AF level may also be measured at 53 with a digital voltmeter (e.g. UGD 51). Frequency response and linearity measurements are also possible in this way.

Distortion measurement:

The CCITT filter must be cut off. Depending on the frequency of the AF generator, depress the DISTORTION button 1 kHz or 300 Hz. Display 2 indicates the distortion factor of the AF signal; it must be < 1%. If distortion is measured at 53 with an external distortion meter, other AF-generator frequencies may be used.

3.2.19 Checking the Modulation

3.2.19.1 Amplitude Modulation

Measuring modulation depth

Connect a modulation meter to the RF socket 49 . Switch the SMPU to receiver test and enter RF frequency (e.g. 10 MHz), RF level (e.g. -40 dBV), modulation frequency of 1 kHz and modulation depth. Depress MODULATION INT. AM 37 . With a modulation frequency of 1 kHz the modulation depth entered must be accurate to within ±3%. When depressing the centre button VAR. 5 , the modulation depth can be varied with the VARIATION knob and linearity measured with the external demodulator. The left button VAR. 5 is to be depressed for frequency-response measurements.

Measuring modulation distortion

Apply the demodulated AF signal from the demodulator to the AF socket 52 . When button 10 DISTORTION 1 kHz is depressed, distortion is displayed on 2 ; it should be < 3% with 90% modulation.

Checking AM with electronic attenuation standard cut in

Depress button VAR. DC 34 . Enter RF level of 99% via AM button 17 and modulation depth of 90% via button FM 17 . The indication of modulation depth must correspond to the value entered, independent of the RF level setting (10% to 99%).

3.2.19.2 Frequency Modulation and Phase Modulation

Checking the unsynchronized frequency

Depress button FM DC 32 ; synchronization of the RF is thus cut off. Set the SMPU for duplexer test (56); enter RF frequency of 30 MHz and RF level of 0 dBV; depress MODULATION INT. FM 37 and CHECK 41 . The frequency of the unsynchronized RF signal is displayed on 1 .

Measuring frequency deviation and phase deviation

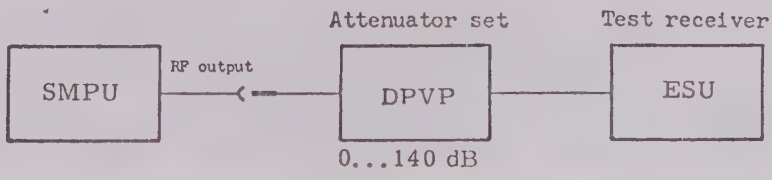
Connect an unmodulated RF signal generator (e.g. 10-MHz crystal oscillator) to 49 or 48 . Depress XMITTER 58 , RF LEVEL (ON) 43 , MODULATION INT. FM (or M) 37 and MOD. MEAS. FM (or φ M) 36 and adjust for 0 dBV on 4 . Enter AF of 1 kHz and desired frequency deviation or phase deviation. Meter 14 indicates the frequency or phase deviation. The entered deviation must be accurate within ±4%. When the centre or left button VAR. 5 is depressed and the VARIATION knob 25 turned, the deviation as a function of modulation frequency, i.e. linearity, can be observed on meter 14 . The modulation frequency is displayed on 2 and FM deviation in kHz or φ M deviation in rad on 3 .

Measuring modulation distortion

Connect socket 26 to socket 52 . Settings as for the measurement of frequency deviation or phase deviation; also press button DISTORTION 1 kHz 10 . The distortion indicated on 2 should be < 1%.

3.2.20 Measuring RF Level Accuracy

Test setup



Vary the attenuation entered into the SMPU and the attenuation of the attenuator set in opposite direction, so that the sum of the two values remains constant and produces a constant deflection on the test receiver.

To cover all settings it is sufficient to proceed up to 80 dB in BCD code (1-2-4-8). Finally check the attenuation at 100 dB. Above 141 dB up to 399 dB the OVERFLOW lamp must light.

3.2.21 Checking the Function Control

The check of the function control can be programmed or manual. If a fault appears, both possibilities should be utilized to exclude the possibility of an error in the input units Y2, Y24 or data coupler Y5.

The static outputs can be checked by entering certain ASCII signals or pressing the corresponding button according to Table 5-1; the ASCII signals are given in Table 5-2.

The illumination of the variation buttons and the variation of the corresponding quantity must correspond to the variation selected.

With internal modulation, the physical unit changes with the type of modulation. When external modulation is measured, the display is in voltage. Depending on the unit displayed, the associated value changes when a variation is made.

To check the function control including the jump instructions, it is sufficient to call up the receiver test and the duplexer test. The settings must correspond to those of Table 4-1. Setting and resetting of all buttons should be checked by referring to this Table.

If a quantity is varied quickly the BUSY indicator lights. It must go out immediately after the variation concerned has been completed.

If the program SN (45) is called up, modulation is switched on and off in position SN of 51 and the 1-kHz filter in position SINAD. In a distortion measurement the selected single-tuned filter (300 Hz or 1 kHz) is switched independent of the position of switch 51 .

The combined operation of function control, SMPU micro computer and counter Y4 is checked in frequency counter operation. Signals should preferably be applied to 52 and 49 or 48 .

With the XMITTER button 58 depressed, the RF must be counted, with RECEIVER 57 and MOD. GENERATOR EXT. 38 the AF, and with XMITTER 58 plus MOD. GENERATOR EXT. 38 the RF and the AF.

To check the driving levels for deviation measurements depress buttons XMITTER 58 and MOD. MEAS. FM 36 , then switch on an RF level of 0 dB with button 43 and connect BU47 to BU48. The RF frequency must increase by 100 kHz $\pm\Delta f$. If negative deviation (button 40 MOD. INDIC.) is measured, the internally measured frequency decreases by 100 kHz $\pm\Delta f$.

4. Circuit Description

4.1 Electrical Function

4.1.1 Stabilizer Y1

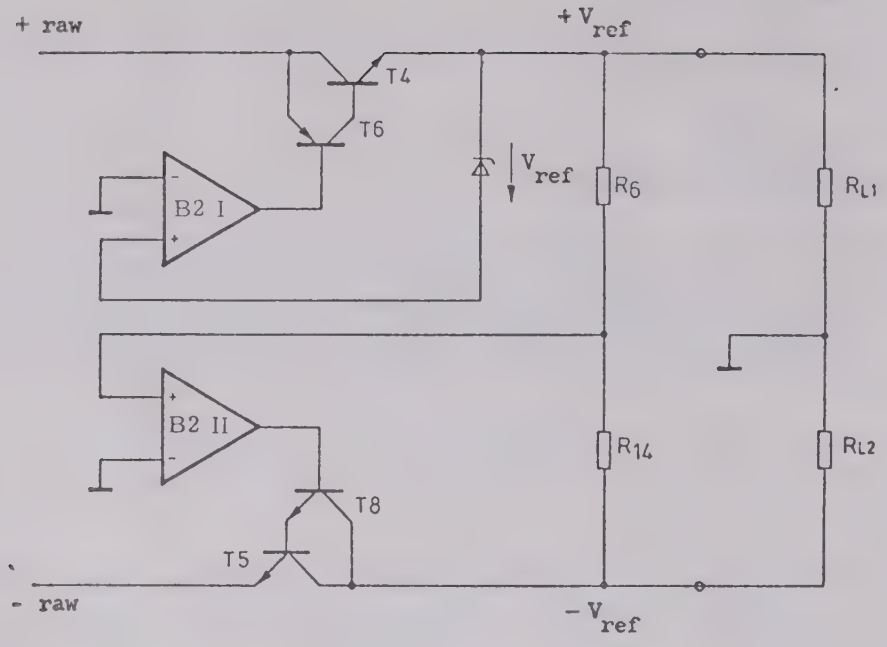
See circuit diagram 239.1000 S Bl. 3

The ±15-V stabilizers are of equal design. The integrated regulators B5 and B6 control the series transistors T2 and T3 on the chassis. The positive voltage is regulated in the +15-V circuit and chassis potential in the -15-V circuit. Both circuits are overload proof. Potentiometer R52 is used to adjust the +15-V voltage, R56 the -15-V voltage.

The -10-V voltage for the computer modules is derived from the -15 V by the Darlington stage T9, T14 in voltage follower configuration. The nominal value is adjusted with R63.

The -20-V stabilizer uses the integrated regulator B4 and series transistor T10. Chassis potential is regulated. The circuit is overload proof. The -20-V supply is used for the control of the FET switches and, in the analyzer mode, for cutting off the diode of the power meter.

The +5-V stabilizer supplies all TTL circuits. The raw +7-V voltage is used to supply the lamps and the LED's of the hexadecimal displays. The input voltage of the emitter follower T12 is produced by full-wave rectification with Gl 11 and Gl 13. The anodes of both rectifiers are at chassis potential. The bridge-type rectifier Gl 10 to Gl 13 produces twice the voltage and supplies the +5-V regulator Bl. This controls the series transistor T12. The voltage drop across R73 is adjusted to the base-emitter voltage of T12 by means of R71.



Basic diagram

+8-V stabilizer

The supply voltages for the switching motors of the attenuator set are derived from the +8-V stabilizer. The positive raw voltage is used for the RF switches. The positive voltage is regulated with the operational amplifier B2I and series transistors T4 and T6, so that the voltage drop across the load R_{L1} is equal to the reference voltage V_{ref}. The control circuit consisting of voltage divider R6, R14, operational amplifier B2II and series transistors T5, T8 makes the negative voltage follow up the positive one.

When the attenuation of the attenuator set is changed, the positive-going edge of the trigger pulse appearing at ST3.7 sets the monostables B7I and B7II. They keep the reference voltage V_{ref} across the reference diode G1 8 at 15 V for a period of 4 ms. Then the reference voltage is switched to 10 V for 31 ms by transistor T11, and to 0 V in the reset state by T7. The intermediate store B8 stores trigger pulses that arrive during a switching time. When the monostable has reset, these pulses are triggered again so that the attenuator is set to its nominal value.

4.1.2 Input Units of SMPU

Input unit Y2 of Control Unit

See circuit diagram 239.4380 S

The manual settings of the SMPU are made by way of the input unit Y2 of the Control Unit and input unit Y24 of the Indicator (for description of Y24 see below). The input keys include Hall generators with amplifiers and Schmitt triggers. Their outputs, with

collector open, are at H potential in the reset state. When one of keys S13 to S51 is depressed, the corresponding output turns L; an address associated with the key is coded in positive logic via a diode matrix and is stored in the function control Y3, which applies TTL level to the corresponding driver transistor of the indicator lamp.

The input unit also contains the buttons S1 to S12 and a diode matrix for figure entry. The figures are coded in negative logic and applied to the A/D converter Y6. The clear line is taken direct to the micro computer Y7.

When the VARIATION knob on the front panel is operated, the electronic variation Y29 applies two signals in phase quadrature to the input unit (see circuit diagram 239.5111 S). The pulses resulting at the monostables B5I, II produce an address for positive or negative variation depending on the direction of rotation of the knob.

Input unit Y24 of the Indicator

See circuit diagram 41105/2-3 S

The input unit of the SMPU Indicator also includes a diode matrix driving the function control Y3.

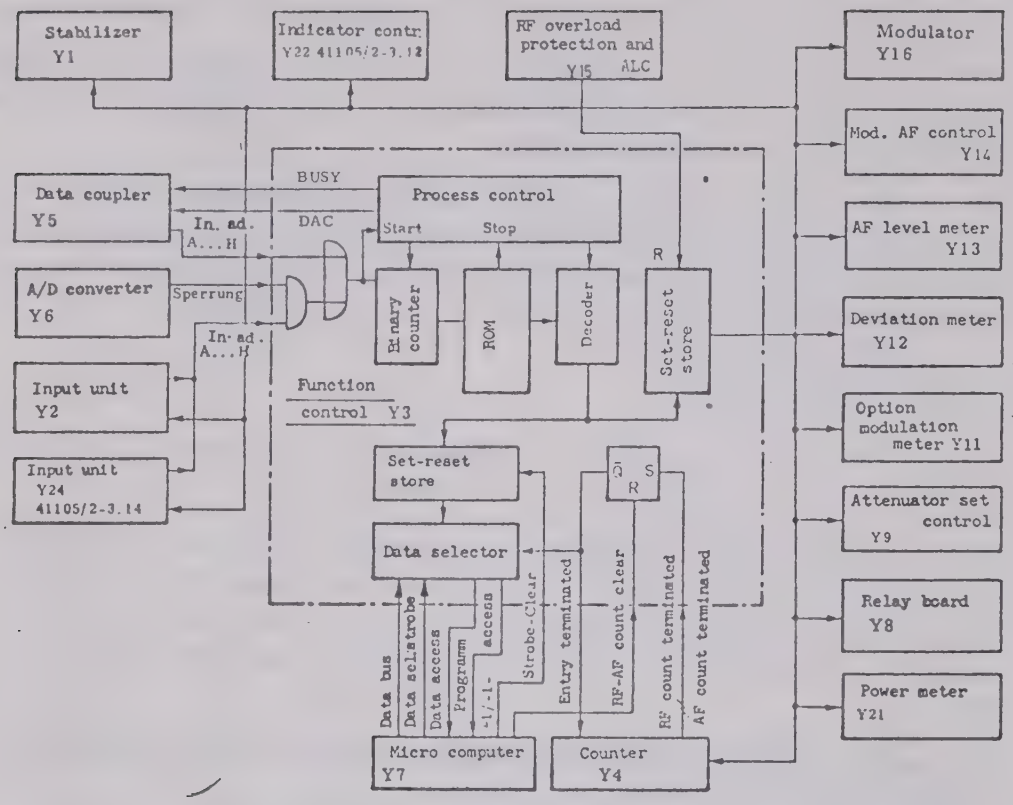
An integrated coder, B4, is used to enter the level-measurement ranges. The indicator lamps of the variation buttons and of the level-measurement ranges are controlled by the decimal decoders B1 and B3. The lamps of the modulation-measurement ranges I and II and those of the 1-kHz and 300-Hz filters are controlled by the peripheral drivers B2 and B5.

The test signals of the power meter Y21 at ST2.7 and of the AF level meter Y13 at ST1.13 are applied to the meters.

4.1.3 Function Control Y3

See circuit diagram 239.2812 S

The function control performs the static settings of the SMPU subassemblies according to the measurement tasks. In transmitter tests, for example, it activates the frequency counter, deviation meter and power meter. It is operated with TTL levels.



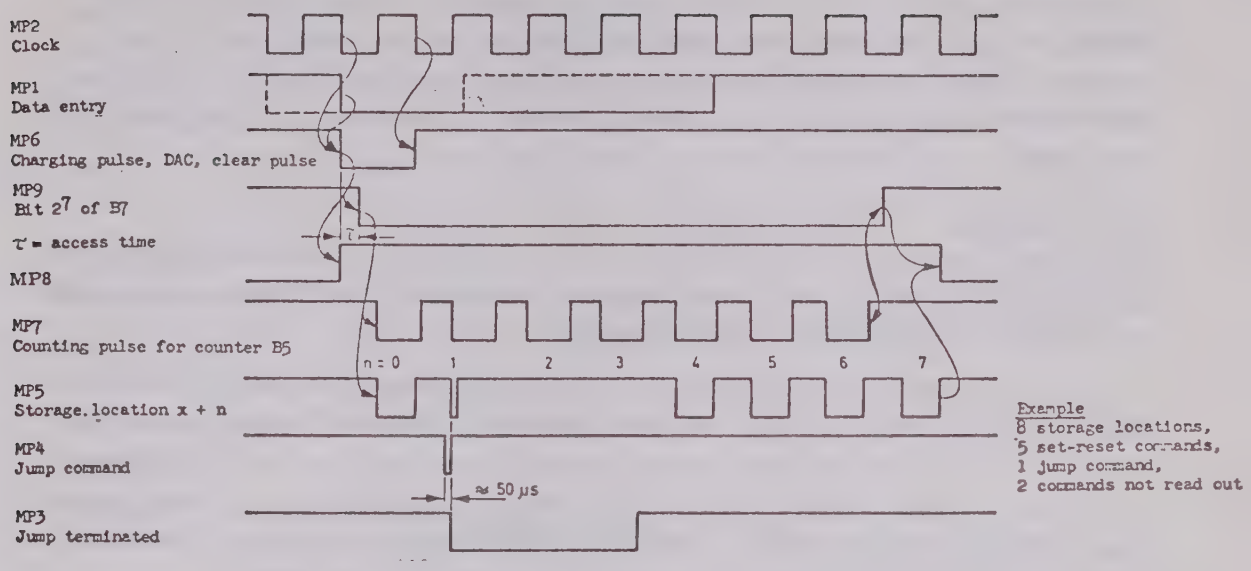
Block diagram

The heart of the function control subassembly is the ROM B7. It has 256 storage locations of 8 bits each and contains the various logic functions for each button or each program command. The storage contents for different states are listed in Table 4-1. By the press of a button or by a corresponding program command in conjunction with the process control, individual storage locations are read out and the storage words are decoded by the demultiplexers B11 to B16. These set or reset the flip-flops B17 to B19, B21 to B30 and B51. The outputs of the flip-flops drive the data selectors B20 and B35 either direct or via the intermediate stores B31 and B33, or they are connected to the control inputs of the individual subassemblies via TTL gates and several basic logic functions.

Process control

The following pulse diagram illustrates the process control by way of an example.

Pulse diagram of process control



The press of a button or a programming command (two ASCII signals) applies an initial address x to the binary counters B5 and B6. The address lines A to H change from H state to the address state and produce a negative-going edge at MP 1. This sets the J-K flip-flop B4I. The J-K inputs of the second flip-flop B4II are thus at H level unless the BUSY line at the AND gate B43III is at L. H level at the J and K inputs means that the flip-flop is set by the next negative-going edge of the pulse from MP2. The output $\overline{Q}$ changes from H to L, clearing the flip-flop B4I. At the same time the address is stored in the binary counters B5 and B6, flip-flop B37II cleared, stores B17, B18, B19, B27 and B51I reset via B39II and the DAC flip-flop in the data coupler Y5 is set by the trailing edge.

Clearing of the flip-flop B37II releases the gate B43I and changes the BUSY connection at B48III from H to L. No new address can thus be entered into the binary counters. Gate B47III is at the same time released and the pulse from MP 2 has access to the decimal decoder B9.

The initial address entered into B5 and B6 is conveyed to the address inputs of ROM B7. The 8-bit word stored with this address x is available at the output after an access time of about 600 ns. H level of the clock pulse releases this word via the D input of the decoder B9. The 2^7 data output MP 9 of the ROM B7 controls through its logic state the counting pulse for the counter B5. At L state the gate B44I is open and the rising edge of the counting pulse at B5 increases the initial address x in unit steps until a word whose 2^7 bit is at H level is read out. From this instant the counting pulse is inhibited; the counters have reached their final address.

The bidirectional counter B10 permits a maximum of 13 storage commands to be skipped. A storage word whose data lines 24 to 26 (pins 8 to 10 of B7) are at H, changes the decimal output 7 of B9 to L. Thus the remaining data 20 to 23 are loaded into the counter B10. The data output via B47 is inhibited and the count gate B44I for the counting pulse of the address counters is kept open. The pulse from MP 2 reduces the count of B10 until the state 0 is reached. The max/min output stops B10 and opens the data output.

Other functions

The function control has the additional task of supplying particular data combinations to the micro computer Y7 via the data selectors B20 and B35. The micro computer executes the program, depending on the data concerned.

The function control applies a TTL signal to the micro computer via the program access line. L level on this line makes the micro computer jump from an internal access loop into a main access loop and scan the data present at the data selectors via the data bus and the two data selector strobes. When a routine is terminated, the micro computer resets the set flip-flop (B34I, II, B36I, II or B37I) with the associated clear line (RF count terminated, AF count terminated, +1/-1 clear or strobe clear).

In the frequency count mode the flip-flops B37I and B36II are set by the counter Y4 after counting and reset by the micro computer Y7 via the RF-AF-count-clear line after entry of the counter contents. The entry-terminated output inhibits the counter in the meantime.

The BUSY output is at L when an entry is made and when the micro computer executes a program. At this state it inhibits both the manual entry via the A/D converter Y6 and via the function control Y3, and the programmed entry via the RED logic in the data coupler Y5.

With the test programs for 12-dB and 20-dB sensitivity and for S/N ratio, the micro computer can switch the modulation (SINAD $\hat{=}$ H) or the single-tuned filter (SINAD $\hat{=}$ L) on and off through the line S/N meas. In distortion measurement the selected filter is switched on and off through this control line.

4.1.4 Counter Y4

See circuit diagram 239.9817 S

General

The counter consists of the gate time generator, eight decades and count gate change-over circuit, all checked by a logic circuit. A data selector outputs the count. If the counter is activated, it either counts RF or AF permanently or RF and AF alternately. After each count the result is read out by the micro computer Y7; then the next count starts immediately. This process is asynchronous so that handshake takes place via the signal lines "AF count terminated", "RF count terminated" and "entry terminated". The mode is selected statically by the function control Y3 via the lines "AF count" and "RF count".

Gate time generator

The gate time is derived from a crystal-stabilized 10-MHz signal coming from the Indicator. The input level transformer T1 is followed by the 1:10 divider B16. The resulting 1-MHz signal is applied as an auxiliary frequency to the deviation meter Y12, and also to the programmable divider B17, which divides by 10 in AF counting, by 1 in RF counting up to 65 MHz and by 8 in RF counting above 65 MHz. The subsequent divider chain B18 to B22 produces - at the $\bar{Q}$ output of the gate-time flip-flop B14 - a gate time of 1 s with AF counting, of 0.1 s with RF counting up to 65 MHz, of 0.8 s with RF counting between 65 and 500 MHz, and of 1.6 s above 500 MHz.

The logic control circuit provides a well-defined output state for the counter chain (nine-setting = H), stops the counter chain at "RF count terminated" or "AF count terminated" = H.

The final start of the counter chain is ensured by the function control with "entry terminated" = L.

Mode	Division ratio B17	Gate time MP4	AF counting BU20.27	RF counting BU20.$\bar{D}$	$f \gtrless 65$ MHz BU20.26
AF counting	1:10	1 s	H	L	X
RF counting - 65 MHz	1:1	0.1 s	L	H	L
RF counting > 65 MHz < 500 MHz	1:8	0.8 s	L	H	H
AF counting and RF counting	1:10 and 1:1 alternately	1 s and 0.1 s alternately	H	H	L
	1:10 and 1:8 alternately	1 s and 0.8 s alternately	H	H	H

Counter switchover

The count gate B13I is opened by the gate time control during the gate time. Depending on the mode, the AF or RF signal is applied to the count input of the count gate via gates B15I and B15III:

Mode	Count gate switch B15I	B15III	Controlling AF counting	RF counting
AF counting	open	closed	H	L
RF counting	closed	open	L	H
AF counting and RF counting	alternately open and closed for one cycle		H	H

Decade counter

The decade counter consists of the 8 decades B5 to B12. The following table shows to which frequency decades the counter decades are assigned for RF and AF.

	Counter decade							
	B12	B11	B10	B9	B8	B7	B6	B5
RF	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz	100 MHz
AF	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	-	-	-

Prior to each count the decade counter is reset to 0 by the logic control circuit. The count signal is applied from the count gate. The result is conveyed to the data selector.

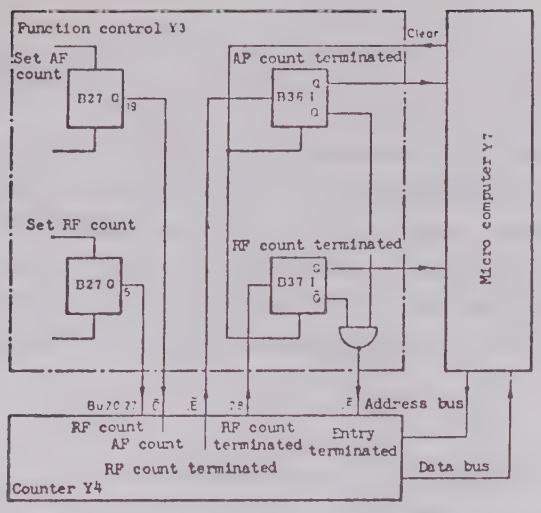
Data selector

When the count is terminated, the result is applied with 8 x 4 bits in BCD code parallel to the data selector B1 to B4 and is offered to the micro computer for serial readout. The micro computer can select the results of the individual decades via the address bus and thus convey the corresponding BCD figure to the data bus (see table). Addressing and data output are in positive logic.

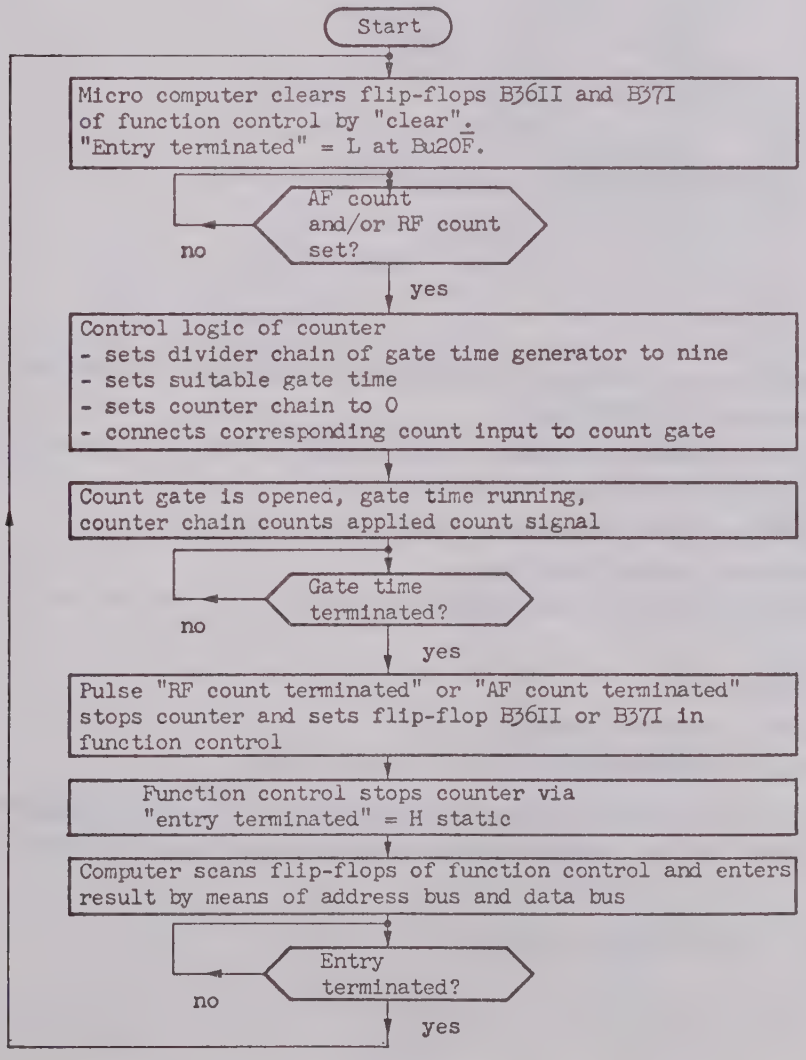
		Decade address							
		0	1	2	3	4	5	6	7
Address bus	A	L	H	L	H	L	H	L	H
	B	L	L	H	H	L	L	H	H
	C	L	L	L	L	H	H	H	H
RF decade		10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz	100 MHz
AF decade		1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	-	-	-

Logic control circuit

This sequential circuit controls the various counts and helps in the transfer of the results to the micro computer. The following simplified diagram shows the operation of counter, function control and micro computer. The flow chart explains the counting steps.



Functional diagram of count


Start
Micro computer clears flip-flops B36II and B37I of function control by "clear".
"Entry terminated" = L at Bu20F.
AF count and/or RF count set?
no
yes
Control logic of counter
- sets divider chain of gate time generator to nine
- sets suitable gate time
- sets counter chain to 0
- connects corresponding count input to count gate
Count gate is opened, gate time running, counter chain counts applied count signal
Gate time terminated?
no
yes
Pulse "RF count terminated" or "AF count terminated" stops counter and sets flip-flop B36II or B37I in function control
Function control stops counter via "entry terminated" = H static
Computer scans flip-flops of function control and enters result by means of address bus and data bus
Entry terminated?
no
yes

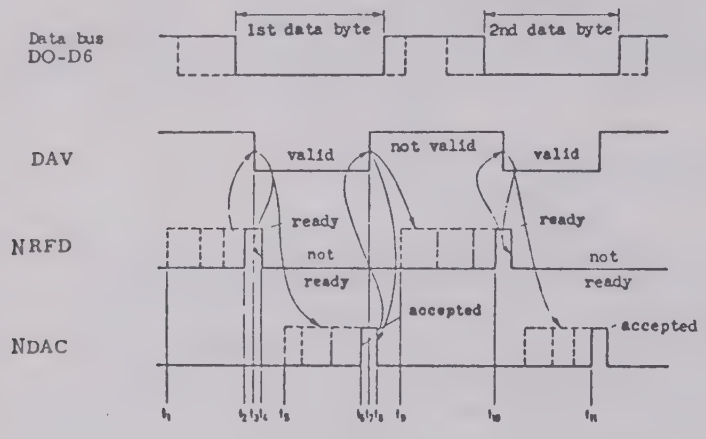
Flow chart of counting

4.1.5 Data Coupler Y5

See circuit diagram 239.9930

Data exchange

Programming and data transfer in the SMPU are in compliance with the IEC recommendation. All programming signals are in the international ASCII 7-bit code. Data transfer is asynchronous, meaning that the system always waits for the slowest piece of equipment. Data transfer and acceptance are controlled by three-wire handshake by means of the three control lines NRFD (non ready for data), NDAC (non data accepted) and DAV (data valid). The time sequence of the programmed data exchange is shown by the following pulse diagram.



t_1 to t_2 Equipments addressed as listeners (receiver) signal to talker (transmitter) readiness to accept data (NRFD = H).

t_3 Talker signals to listeners validity of data present on data bus (DAV = L).

t_4 DAV = L sets RFD to L (not ready for data).

t_5 to t_6 Listeners signal to talker acceptance of data (NDAC = H).

t_6 All equipments have accepted the data.

t_7 Talker cancels DAV (DAV = H). Then cancels data and conveys new data to data bus.

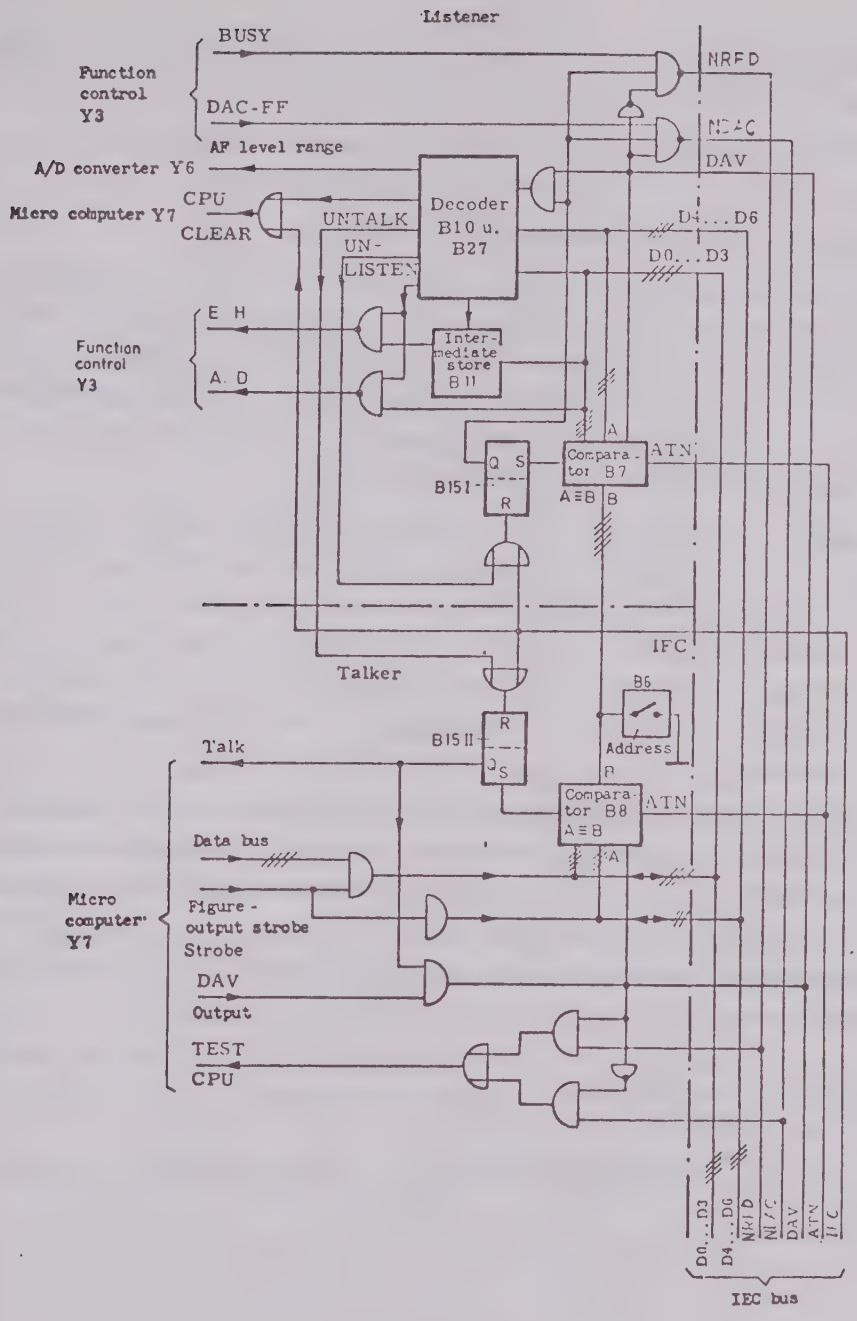
t_8 DAV = H sets NDAC to L.

t_9 to t_{10} Listeners signal processing of data.

t_{11} All equipments have processed the data; new cycle starts.

As can be seen in the diagram, the control lines NRFD and NDAC must be of open-collector design and combined by WIRED AND to permit asynchronous operation with several equipments.

The SMPU can operate as listener and as talker.



Block diagram

Circuit description

If the control line ATN (former designation MRE) is at L level and if DAV is active (0 V), the comparators B5, B7 and B8 compare the data word present on the data bus with the equipment address set on B6 and if the two coincide set the corresponding address store B15. The LED's G1 1 and G1 2 indicate the set address.

In the listen mode gates B20I and B20II are released to signal data acceptance (NDAC) and processing (NRFD) to the monitoring unit. With figure entry including the decimal

point and with the program commands from column 5 of Table 4-2 (in the Annex), the NDAC signal comes from the function control Y3 via the flip-flop B21I.

With the other program commands, NDAC is derived from the negative-going edge of the DAV signal and delivered via B24 and B21II with a delay of 200 ns.

RFD is combined directly with BUSY, ATN and DAV in B17 and B18.

The SMPU can be programmed with the signals listed in Table 4-2. The different ASCII signals are decoded in the decoders B10 and B27 if DAV is active, i.e. DAV = L. The corresponding subassembly - AD converter Y6, function control Y3 or micro computer Y7 - is driven by the decoded signals. The function control Y3 must be driven with two ASCII signals via the data bus A to H. The first ASCII signal (a 0) is temporarily stored in B11 and released simultaneously with the second ASCII signal (P).

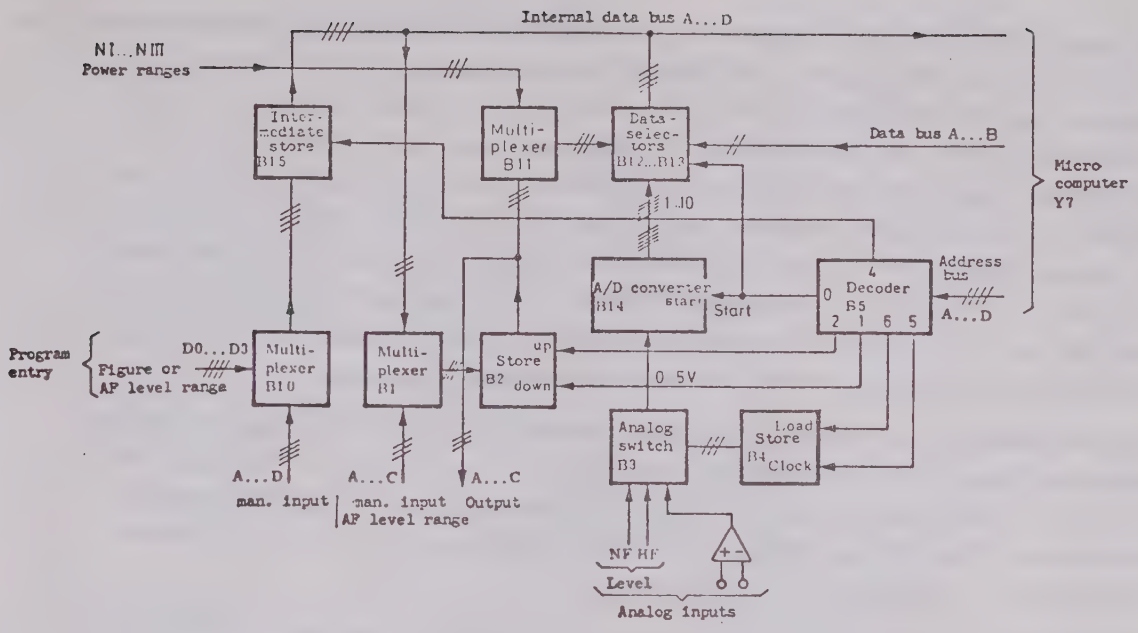
In the talker mode of the SMPU the control lines NRFD and NDAC are scanned. If DAV is at H level, the micro computer Y7 waits via the logic of B19 for the NRFD signal and after NRFD has become active changes the DAV line to L. In this phase it waits for the NDAC signal and after arrival cancels DAV; DAV returns to H. Then the micro computer conveys new data to the IEC bus via the data bus and the figure output strobe and waits for the NRFD signal. The end of a data output is signalled by the ASCII signal CRT (carriage return) or LFD (line feed).

The control line IFC is at H in the rest condition. The active condition (IFC = L) causes the address stores to be cleared immediately so that all data and control lines of the IEC data bus are set to H. Simultaneously the micro computer Y7 is set to its basic state via the IFC-clear line. The ASCII signals SDC (selected device clear) in the addressed state and DCL (device clear) in the unaddressed state have the same reset effect on the micro computer.

4.1.6 Analog/Digital Converter Y6

See circuit diagram 239.9898 S

The A/D converter Y6 is an interface between the micro computer Y7 and the analog measuring units.



Block diagram

The analog values measured are converted in the 10-bit A/D converter B14. Operating with successive approximation, it contains a D/A converter, voltage comparator, clock generator and 10 stores. Conversion time is 20 µs; input voltage range 0 to +5 V. Conversion begins with the rising edge of the start pulse at pin 34 of B14.

The A/D conversion is started by the micro computer Y7 with the decimal decoder B5 via the address bus. The tristate gates B17 are at the same time switched from high impedance to low impedance and the data selectors B12 and B13 are opened. When the A/D conversion is terminated, the computer outputs the 10-digit value and the measurement range via the data bus according to the following table:

Data bus		Data bus of A/D converter			
ST22.19,W	.18,V	ST22.9	.K	.10	.L
B	A	D	C	B	A
L	L	1 (MSB)	2	3	4
L	H	5	6	7	8
H	L	9	10(LSB)	L	L
H	H	L	C(NIII)	B(NII)	A(NI)

A, B, C = measurement range of AF level meter
NI/II/III = measurement of power meter

Prior to an A/D conversion, the micro computer Y7 switches the required analog switch of B3 on by means of a loading or shifting pulse at the shift register B4. The signal applied to the analog switch selects the required measurement range at the 4x2-to-4x1 multiplexer.

The figure entry into the T register of the computer is also made via the data bus of the A/D converter. The figure to be entered from the input unit Y2 is brought to positive logic and TTL level by transistors T1 to T4 and stored temporarily in the tristate store B15. The figure strobe at ST22.26 switches the multiplexer B10 to select B and signals via the figure address line the entry of a figure to the micro computer Y7 via the data coupler Y5 and the function control Y3. The computer with the address word 12 takes the figure from the intermediate store B15. In programmed operation, the figures and the ranges of the AF level meter are entered into the store B15 via the A inputs of the multiplexer B10. Then the figures are entered into the T register of the computer by the handshake method described above.

The level ranges are stored in the up/down counter B2 via the multiplexer B1 when the programmed input strobe is at St22.8. Manual entry is made by way of the input unit Y24 with the manual input strobe at St22.8, via the B inputs of the multiplexer B1. The computer is capable of reducing or increasing the ranges of the AF level meter via the decoder B5 by means of the addresses 9 or 10.

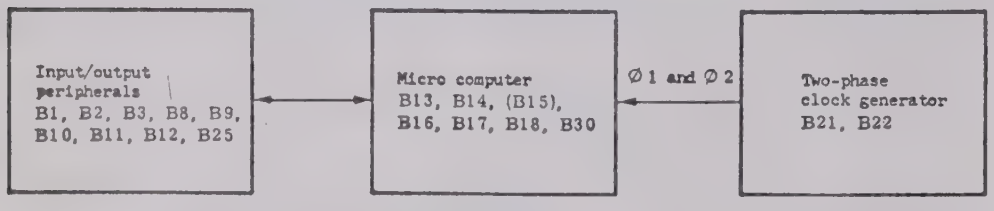
If the computer Y7 is operating (BUSY = L) or if DAV is at L, the entry of the level range is inhibited. The entry of figures and instructions is blocked by the "manual operation inhibition" of the function control Y3.

4.1.7 Micro Computer Y7

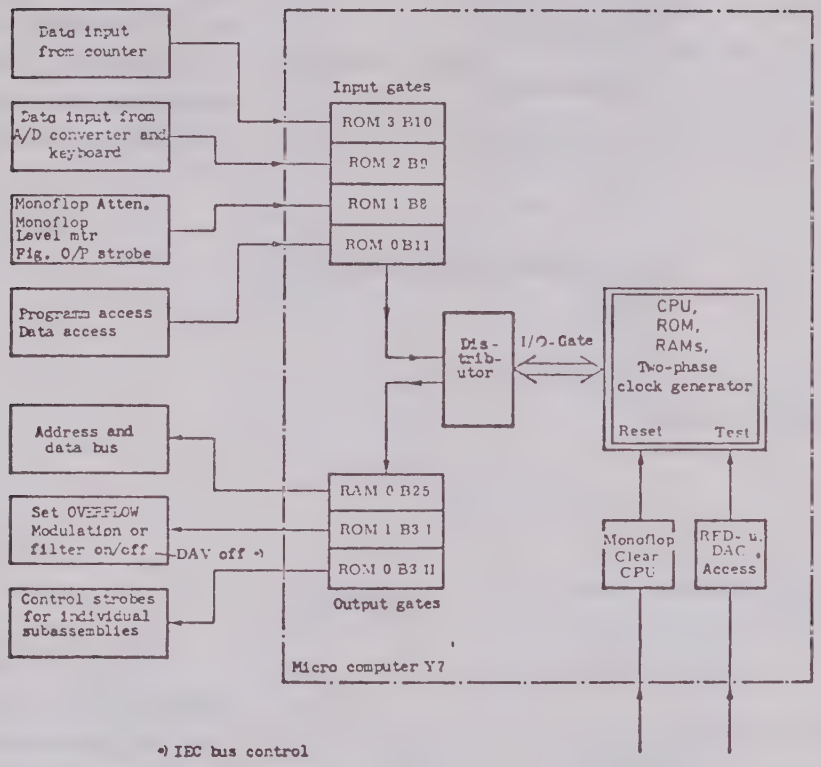
See circuit diagram 239.9975 S

4.1.7.1 System description

The computer board comprises several functional units which can be divided into three blocks:


Input/output peripherals
B1, B2, B3, B8, B9, B10, B11, B12, B25
Micro computer
B13, B14, (B15), B16, B17, B18, B30
Ø 1 and Ø 2
Two-phase clock generator
B21, B22

More details are shown in the following diagram:



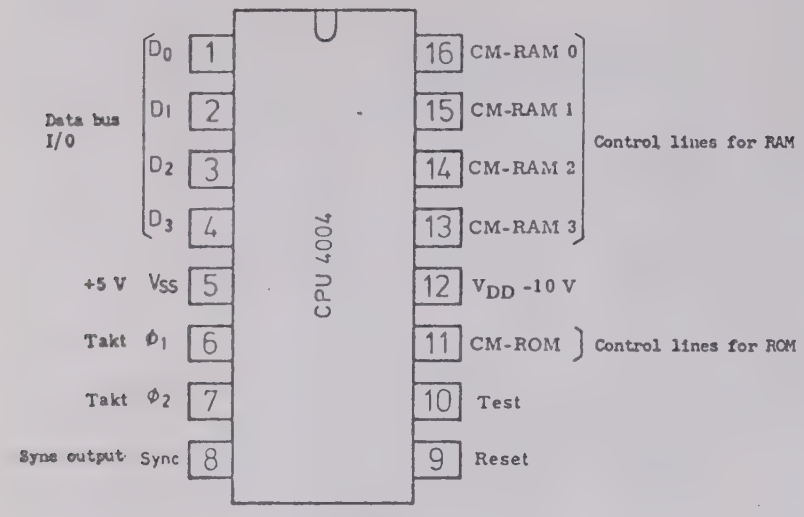
Input/output schematic

The heart of the micro computer Y7 is the central processor unit (CPU), which performs all checking and data transfer functions of the computer board. It is completed by a ROM for program storage, RAM's for storage of working data and input/output chips as well as address chips. A two-phase clock is used for synchronization of the functions.

A detailed description of the operation of the individual micro-computer modules and of ROM programming would go beyond the scope of this manual. Please refer to the MCS-4 manual of Intel.

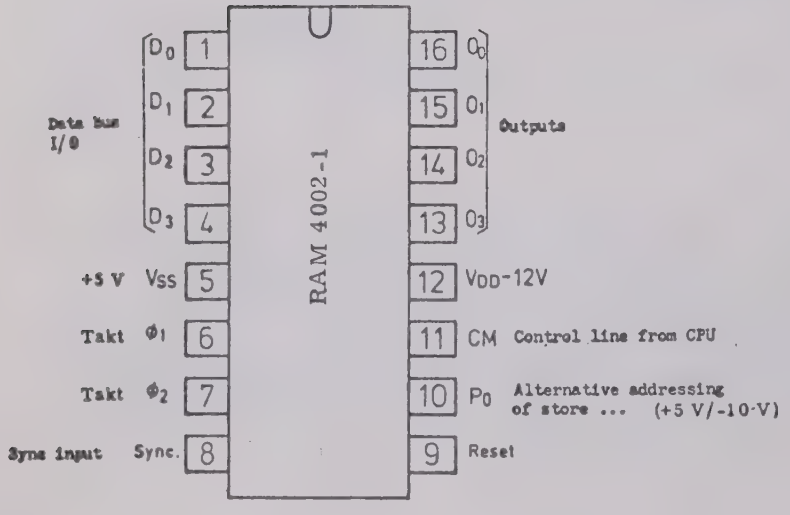
4.1.7.2 Micro-computer Modules

CPU



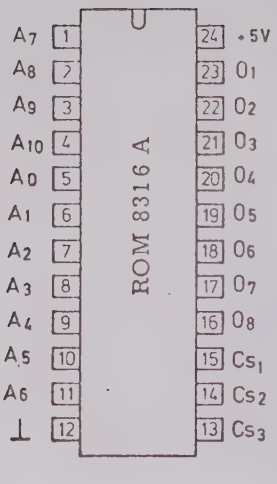
The CPU B18 is the coordination point for all micro-computer modules. It organizes the internal and external data sequence, produces a sync signal and performs the instructions from the ROM B14.

RAM



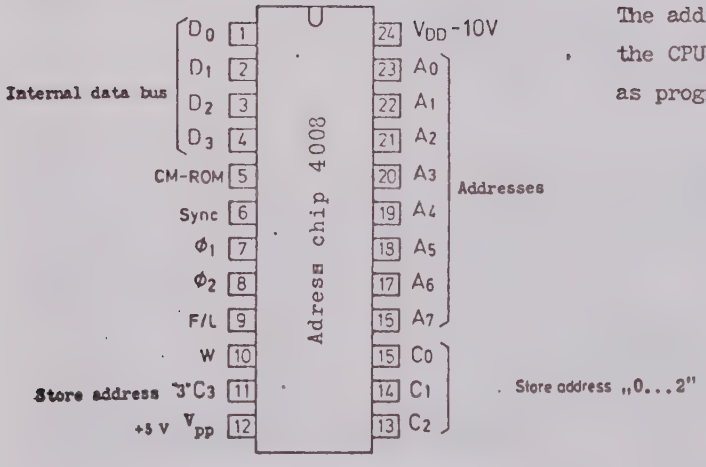
The RAM's B17 and B30 are of type 4002-1 in P-MOS technology. Storage capacity is 320 bits, organized in four registers of 20 x 4 bits each. Output is via a 4-bit output bus which is controlled by an internal control line. The RAM's serve the purpose of storing the input data and the results.

ROM



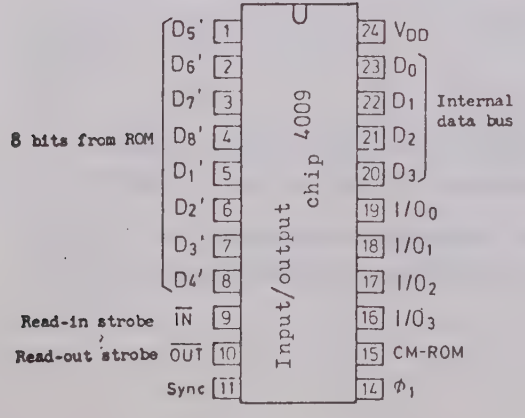
The ROM B14 is of type 8316 A in N-MOS technology. Its capacity is 16 384 bits, organized in 2048 x 8 bits. It operates with TTL levels; access time is below 1 µs. The program sequence is stored in the ROM. From there the CPU receives the instructions, which it performs step by step.

Address chip



The address chip B16 (type 4008) connects the CPU B18 to the ROM B14, which is used as program store.

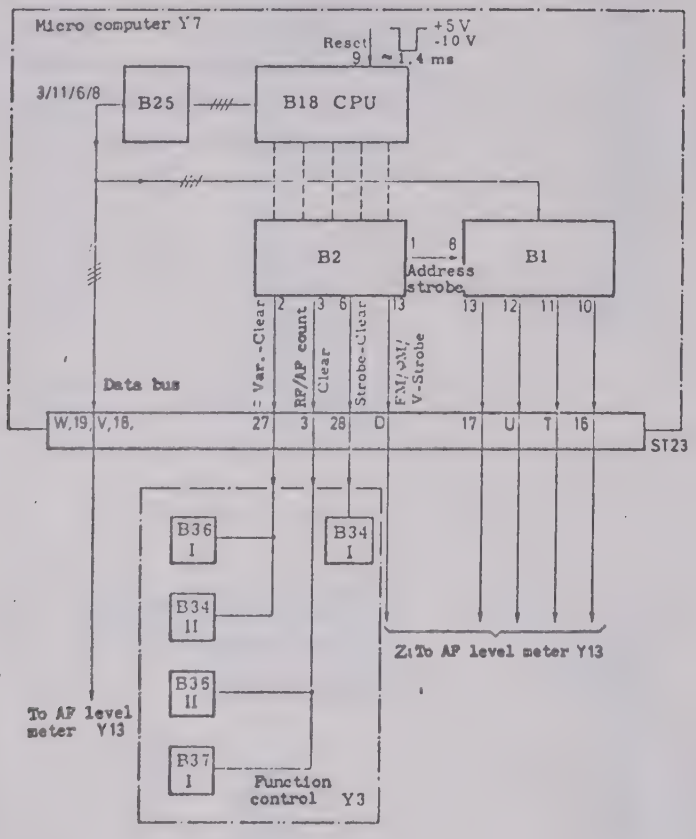
Input/output chip



The input/output chip (type 4009) transfers the 8-bit command (pins 1 to 8) from the ROM B14 to the CPU B18. When the computer enters data, an input strobe (pin 9 of B13) is output, which connects the previously selected input gate (pins 5 to 9 of B26) via B12 to the input/output gate (pins 16 to 19 of B13) of the input/output chip B13. If the computer executes a write command, the output data are conveyed to the input/output gate (pins 16 to 19 of B13) and an output strobe (pin 10 of B13) is produced, releasing either of the output stores B3I or B3II.

4.1.7.3 Program Sequence

4.1.7.3.1 Resetting the Computer with the Clear Button



Schematic of reset process

By the operation of the red CLEAR button, the SMPU is set to "start", meaning that a low pulse of 1.4 ms appears at the reset input of the CPU (pin 9 of B18). The program address is thereby set to 0. Resetting of the program counter can be checked at pins 11 to 23 of the address chip B16.

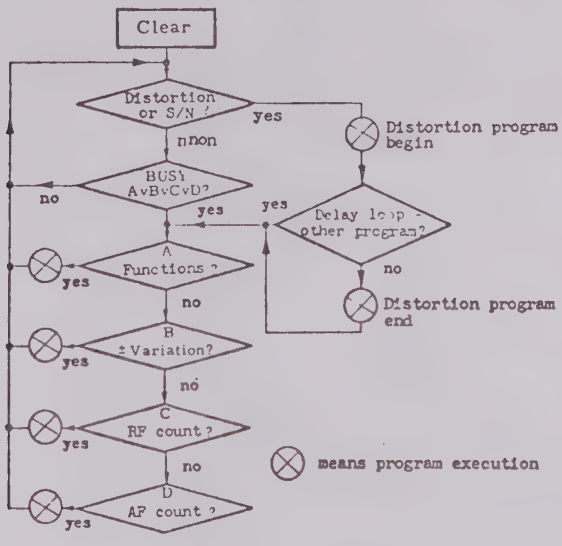
The fresh start of the program first clears the intermediate stores for the keyboard entry. It should be noted that the data previously set (e.g. RF generator, AF generator, attenuator set) are not erased. These set data can only be overwritten but not erased.

Then the flip-flops B37I (AF count), B36II (RF count), B36I (-1 var.), B34II (+1 var.) and B34I (function strobe) in the function control Y3 are cleared. These clear pulses can be measured at contacts 27, 3 and 28 of connector St23 on the computer board.

Next the additional gain in the level meter (for distortion measurement) is set to 1. The address 3 (B1), the FM/φM/V strobe (pin 13 of B2) and the figure 0 are output at the data bus.

4.1.7.3.2 Selection of Program to be Executed

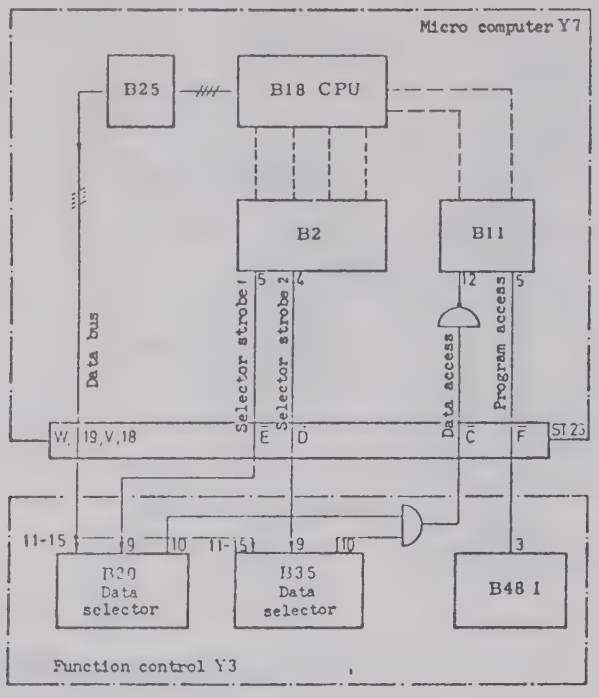
The reset routines are followed by the select routines for the programs to be executed.



Flow chart for main access

Distortion measurement (or S/N measurement at any RF level) is checked first. The distortion condition is internally stored in the computer and cannot be measured externally. If the condition is fulfilled, the distortion measurement routine is started immediately; if it is not fulfilled, all other programs - divided into five main groups - are checked. This access sequence runs as follows: First the BUSY (program access) line ST23.$\overline{F}$ is checked. If it is active (low level), the individual routines are accessed via the data access ST23.$\overline{C}$. If the BUSY line is passive, the distortion condition is checked again.

The following schematic shows the data access sequence.



Schematic of main access

The computer applies a figure, starting at 0, via the data bus to the addressing inputs of the data selectors B20 and B35 in the function control Y3. Moreover it supplies a data selector strobe via St23.$\overline{E}$ or .$\overline{D}$ to pin 9 of these data selectors. While the computer varies the addresses of the data selectors from 0 to 15, all inputs of the data selectors are successively connected through to the output. The output (pin 10) is fed back to the computer and checked as data access. If a program is recognized as active by the computer, it is executed at once. At the end of each program the main-access flip-flops B37I, B36II, B36I, B34II, B34I in the function control Y3 are reset via the corresponding control lines (see section 4.2.7.3.1).

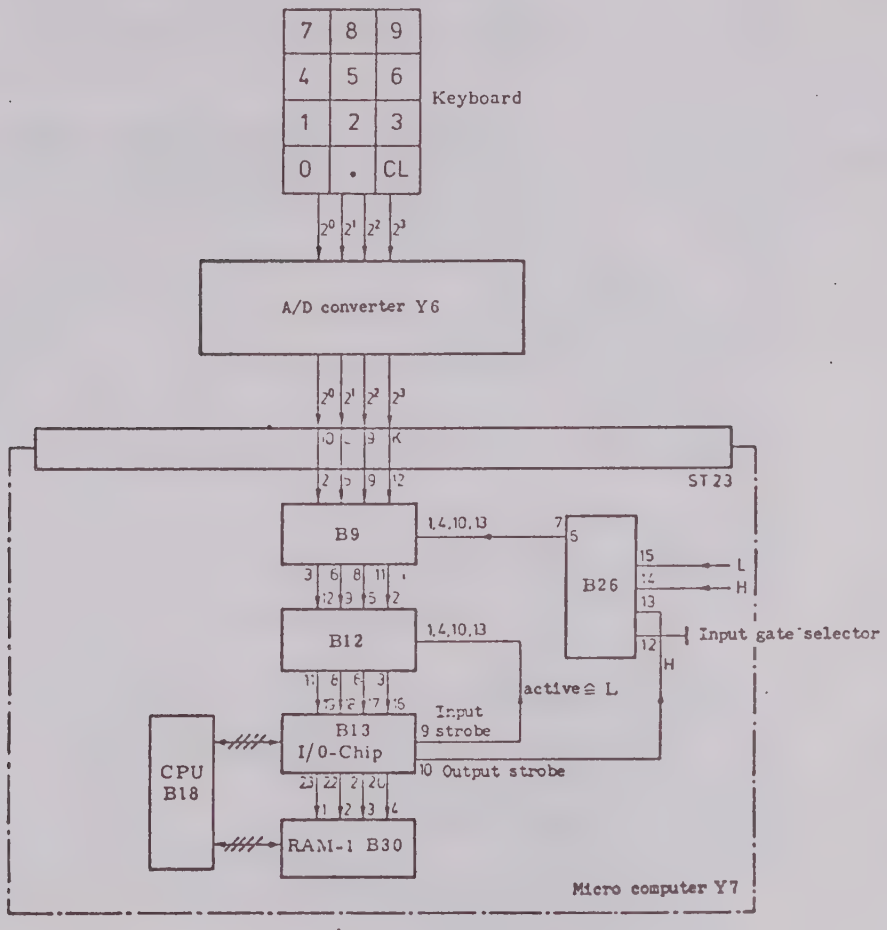
Setting of a program (apart from distortion measurement or S/N measurement) is shown on the SMPU by the BUSY lamp lighting, ending of the program by the lamp going out.

Distortion measurement and S/N measurement are continuous programs, i.e. the individual measurements follow one another until the button DISTORTION OFF or AUTOMATIC TEST OFF is depressed. Since the BUSY lamp does not light during these two programs, the computer is available for all other programs (Fig. 4-1).

4.1.7.3.3 Storing the Data

Entering a figure through the keyboard

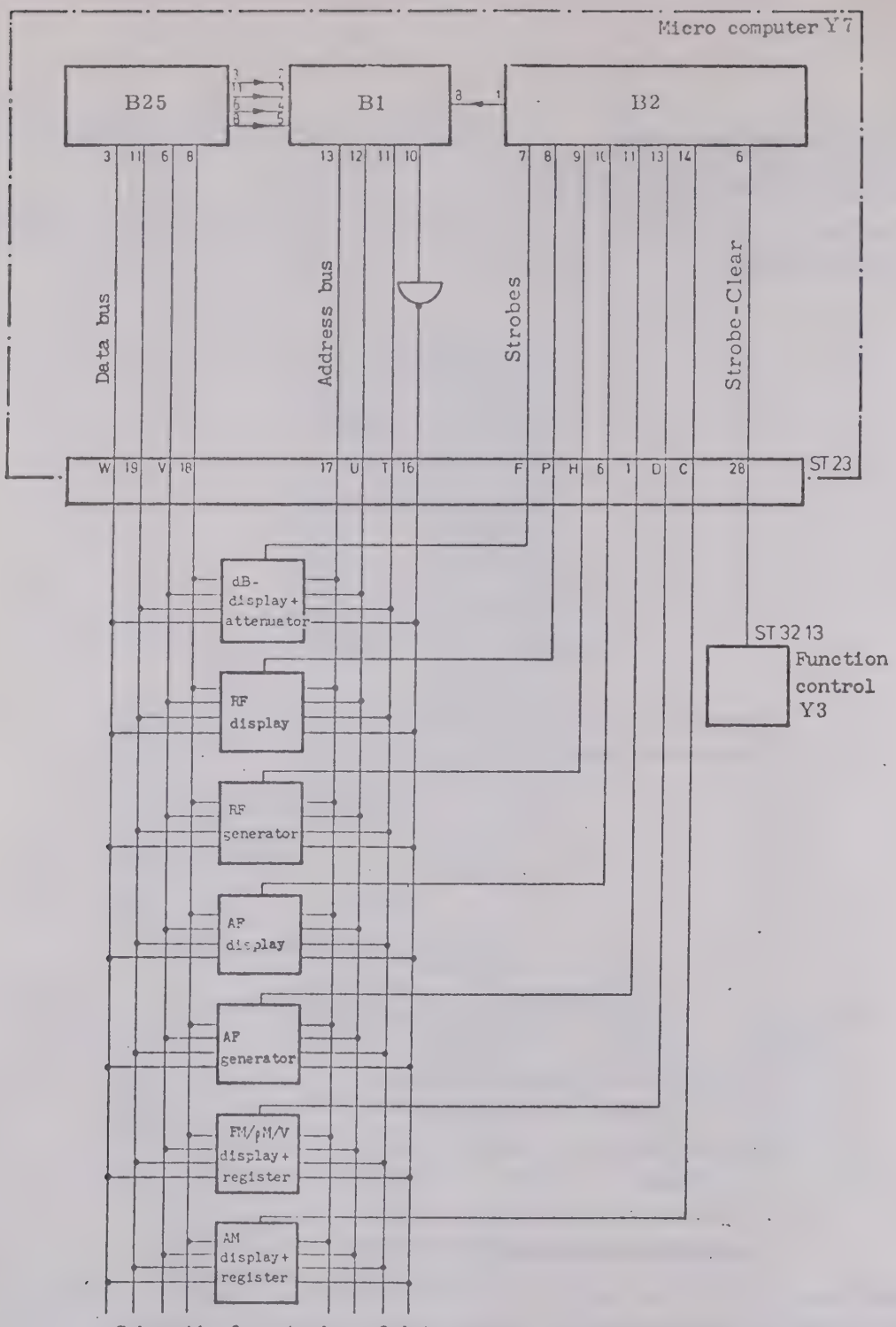
If a figure (0 to 9 and decimal point) is entered via the keyboard, it is stored temporarily in the computer.



Schematic of data entry via keyboard

Each figure and the place held by the decimal point are stored in the computer. The figure (or the decimal point) is conveyed from the keyboard to the A/D converter Y6 (see circuit diagram 239.9898 S), and from there to the computer (ST23.10/.L/.9/.K) at the driver B9. Now B9 (pins 1, 4, 10, 13) and B12 are opened by the micro program, so that the figure can reach the input/output chip B13 and then the RAM-1 (B30). Up to 8 digits and the decimal point can be stored successively in this way.

If next one of the input buttons (e.g. RF, AF, FM) is depressed, the figure stored in the micro computer is displayed, according to the physical unit specified on the button, on the SMPU Indicator and also applied to the register of the Indicator. (Register means the store for setting the appropriate unit, e.g. RF generator).



Schematic for storing of data

First an address is output via the address bus (ST23.17/.U/.T/.16), then a figure via the data bus (ST23.W/.19/.V/.18) and finally the display and register strobe (B2). This sequence is repeated according to the number of digits corresponding to the physical unit, for example 8 times for the RF frequency and 3 times for the RF level. The transfer begins at the address 0 and ends at the highest digit. Both the figures and the addresses are output via the data bus of the computer. The strobes of B2 determine whether the value present on the data bus is an address or a figure. With an address the strobe at pin 1 is active, with a figure the corresponding strobes at pins 7 to 9. The end of entry

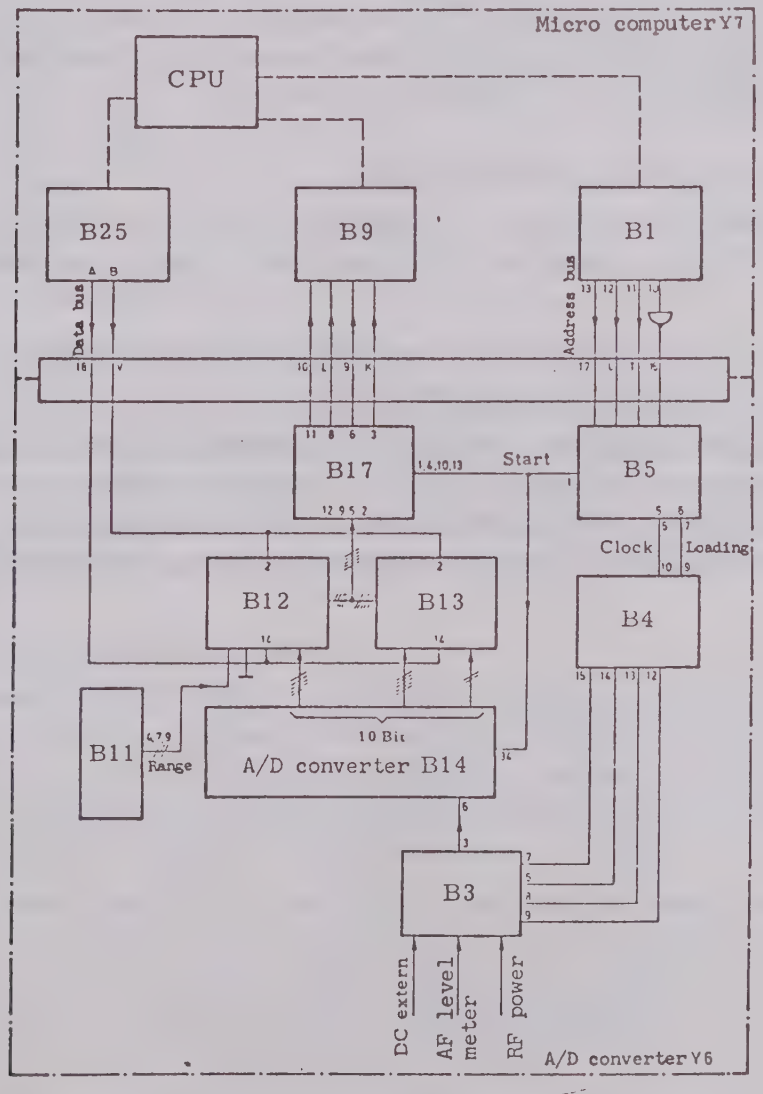
is indicated by the strobe clear at pin 6. For RF and AF there is a display strobe and a register strobe, for all other units one strobe only.

The entry of the AF frequency is a special case. The entered frequency value is converted by the computer into a three-digit figure with a range-identification figure (e.g. 9.99 is converted into 3999). First the three-digit value (address 0 to 2), then the range (address 3) is set on the AF generator.

Measured quantities from counter Y4 and A/D converter Y6

In the RF and AF count modes, an address (0 to 7 or 4) is read out and then the numerical value is entered via the input gate B10 from the counter Y4. The entry begins at address 0 and ends at the highest digit. When the transfer of the count is terminated, the counter is cleared via RF/AF count clear (B2, pin 3) and reset.

The function of the A/D converter Y6 in conjunction with the micro computer Y7 is shown in the following diagram:



Schematic for entering the data from the A/D converter

The A/D converter is controlled by the computer. The control signals are applied to the A/D converter via the address bus (ST23.17/.U/.T/.16). A typical operating cycle is as follows:

First the computer outputs 14 as an address (B1, pins 10 to 13). This causes the A/D converter to output 6 to B5 (circuit diagram 239.9898 S). This pulse loads the figure 14 into B4; as a result, the AF level is through-connected to the output (pin 3) at the analog multiplexer B3. Thereupon this address is erased, the figure 15 appearing on the address bus.

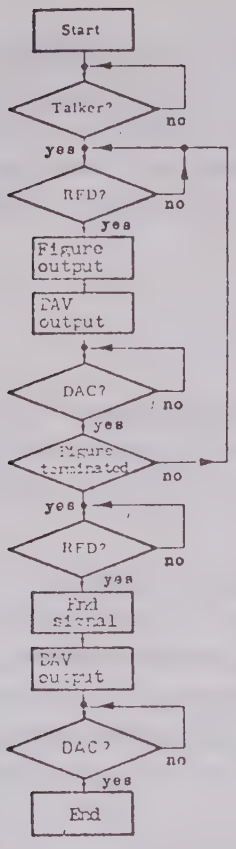
The analog voltage at the output of the analog multiplexer is conveyed via B16 to the A/D converter B14. For the through-connection of the selected analog voltage (DC ext., RF level, AF level) 0 to 2 shifting pulses are applied to the parallel shift register B4, which sets the multiplexer correspondingly. With address 8 on the address bus the A/D converter B14 is started. The digital value is available after about 20 µs at the digital output of the converter. This 10-bit binary value (B14, pins 52, 54 to 72) and the range (B11, pins 4, 7, 9) are checked with the addresses 0 to 3 by the computer via the data bus (ST23.19/.18). The computer enters these 16 bits (4 words of 4 bits each) via the inputs ST23.10/.L/.9/.K from the A/D converter.

4.1.7.3.4 Outputting of Control Commands and Data

With the automatic programs SN or SINAD, the modulation or the 1-kHz filter must be switched on and off by the program. This is performed via the line "SN measurement" ST23.24.

If the RF frequency is $\geq$ 500 MHz, a doubler (option) should be inserted via the control line "doubler" ST23.2, otherwise OVERFLOW is set.

If data are to be output by the SMPU, changeover from listener to talker is necessary (see description of handshake in section 4.1.5). The listener mode means that the SMPU is ready to accept data, while in the talker mode the SMPU is prepared to deliver data. Changeover is made by an external control unit (e.g. Desk-top Calculator TEK 31).



The handshake process is controlled by the micro computer Y7. The sequence is shown in the flow chart to the left. The hardware acts as follows:

Output of figure identification at pin 15 of B2. Then check at ST23.11 whether SMPU is addressed as talker; if so, check for RFD on the test line ST23.7. If this condition is fulfilled, the highest digit of the selected figure is output. The computer sets DAV at ST23.5. The acknowledgement signal DAC is checked at test input ST23.7. If this condition is also fulfilled, the cycle starts again with RFD. The loop continues until all digits that are to be output have been processed. Then the end signal CRT is given.

If one of the conditions TALK, RFD or DAC is not fulfilled, the computer stops until the line concerned fulfils the condition.

Handshake with data output

4.1.7.3.5 Calling Back Data from RAM's

All input data, the A/D converter values, counter contents and results of automatic measuring programs are stored in the RAM's. It is thus possible to transfer these values to the displays and registers of the Indicator. A similar method is used for calling back as for storing (see section 4.1.7.3.3). First an address, then the corresponding digit and finally the associated strobe is output.

4.1.7.3.6 Fully Automatic Programs

An automatic program consists on principle in setting or varying the SMPU to predetermined quantities and reading out the displayed AF level. This determines whether the program is to be continued or terminated. The program runs a loop until the loop condition is fulfilled. An exception are the distortion and the S/N program, which determine only two values, from which the result is calculated.

If an automatic program is started, the AF level range is always selected automatically. The value of the AF level meter Y13 is read out and compared with an upper and a lower mark. Depending on the result of this comparison, the level range is shifted up or down until the level meter is set to the appropriate range.

Prior to read-out of the A/D converter Y6, the computer is stopped for about 250 ms to enable the AF level meter Y13 to reach steady state. This is performed by a Low pulse at the input of B7, whose $\overline{Q}$ output is set to Low for a fixed time. This output is checked by the computer, which decides whether the program has to be interrupted or execution can be continued. The waiting time can be terminated immediately by the figure identification strobe at pin 15 of B2.

4.1.8 Relay Board Y8

See circuit diagram 240.0090 S

The relay board makes floating switching signals available to the device under test (e.g. radiotelephone system), depending on the TTL signals from the function control Y3. The reed relays RS1 to RS3 are operated in transmitter and receiver tests, in measuring the call signal or the squelch threshold.

The RF relays I to III are switched through the switching transistors T1 to T3. Transistor T1 controls the relay contact rs2 between the RF output and the attenuator Y25 (see 239.1000 S Bl. 1). T1 must cut off quickly when the RF protection circuit responds. On the other hand, upon switchover from transmitter to receiver test, the relay must remain off for a short time to prevent the RF protection from responding. C1, R2 and G1 8 ensure rapid cutoff of transistor T1. T1 becomes conductive with the time constant determined by R2 and C6.

The AC coupling of the external FM input is by-passed in DC operation by the reed relay RS7. In mode VAR. DC relay RS5 applies a DC voltage of +1.4 V to the input of the AM-AF attenuator in the mod. AF control Y14. At the same time relay RS4 applies to the output amplifier of the AM-AF attenuator a DC voltage which shifts the modulation characteristic such that no RF level exists at 0% AM and the normal RF level at 100% AM. Both DC voltages are derived by the operational amplifiers B3I and B3II from a reference voltage tapped at R5, R6. The modulation voltage can be adjusted with R11, the shifting voltage with R8.

4.1.9 Attenuator Set Control Y9

See circuit diagram 240.0184 S

The sub-assembly Y9 controls the 22 motors of the attenuator set Y25. The attenuation value is entered serially into the stores B3 and B4 through the data bus ST25.18/.V/ .19/.W. The data is transferred with the address present on the address bus by the dB strobe signal. This signal also sets the monoflop B11. Switching on and off of the RF level also sets the monoflop, via ST25.2, and the trigger pulse of the monoflop (1.5 ms) starts the staircase-shaped supply voltage for the attenuator motors in the stabilizer Y1.

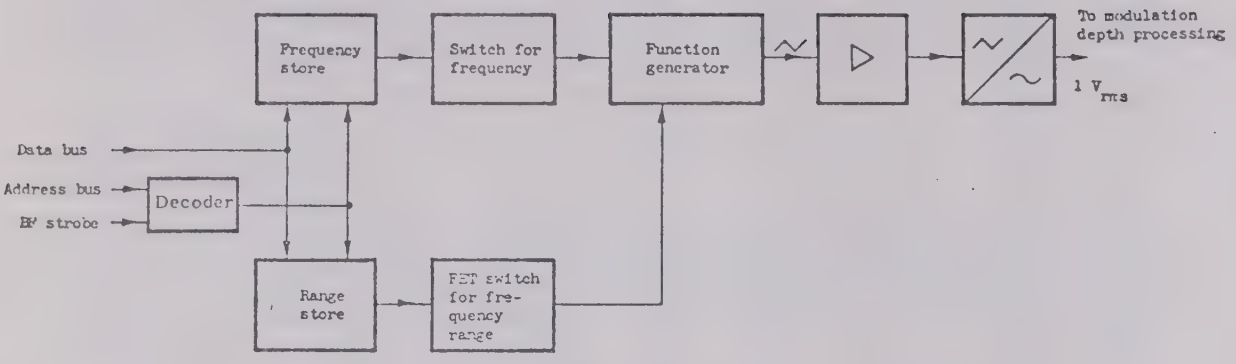
The stored attenuation value is converted from BCD into the 1-2-4-4 code in gates B5 and B6. The attenuation values are listed in the following table.

Attenuation	Attenuation steps									
dB	1	2	4	4	10	20	20	40	40	dB
7 7	H	H	H	L	H	H	L	H	L	
9 9	H	L	H	H	H	L	L	H	H	
1 0 0	L	L	L	L	L	L	H	H	H	
1 1 0	L	L	L	L	H	L	H	H	H	
1 2 0	L	L	L	L	L	H	H	H	H	
1 3 0	L	L	L	L	H	H	H	H	H	
1 3 1	H	L	L	L	H	H	H	H	H	
1 3 2	L	H	L	L	H	H	H	H	H	
1 3 4	L	L	H	L	H	H	H	H	H	
1 3 8	L	L	H	H	H	H	H	H	H	
1 3 9	H	L	H	H	H	H	H	H	H	
1 4 0	L	H	H	H	H	H	H	H	H	
1 4 1	H	H	H	H	H	H	H	H	H	

When the attenuation of 141 dB is exceeded, the micro computer Y7 signals overflow and the driving level for the transistor switches is held at the maximum attenuation of 141 dB. The transistor switches connect the positive or the negative 8-V voltage through, depending on the TTL information applied. If, for example, the input of switch T1 to T4 is at H level, T1 and T3 conduct and the positive switching current flows through T3. If L level is at the input, T2 and T4 conduct and the negative switching current flows through T4.

4.1.10 AF Generator Y10

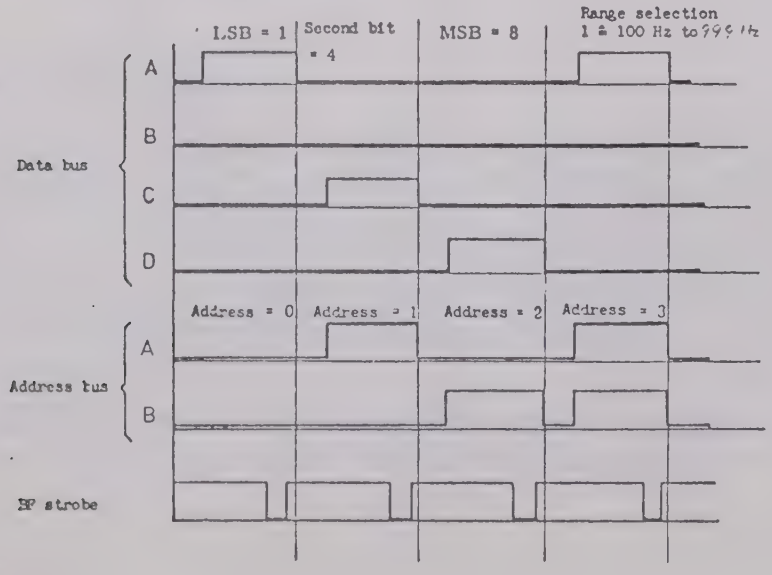
See circuit diagram 240.0255 S



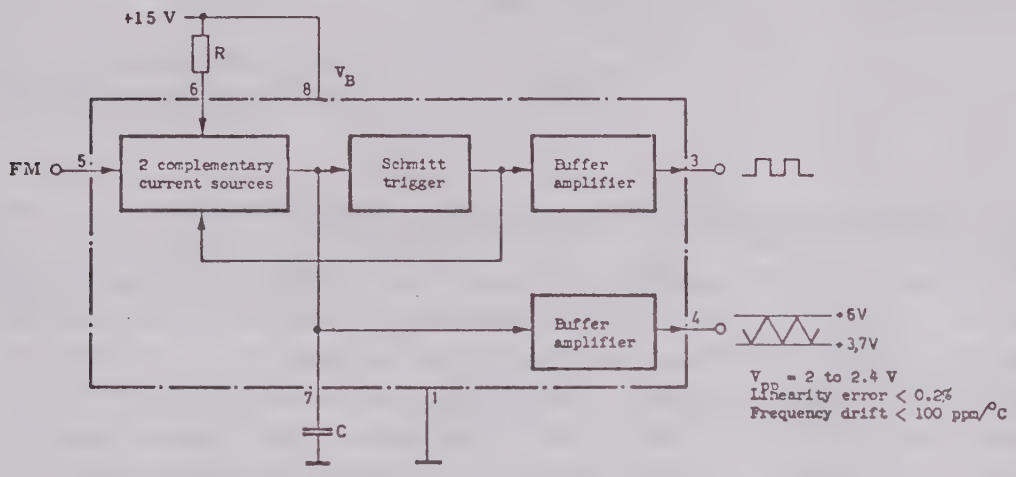
Block diagram

The AF generator Y10 consists of a digital control section with the IC's B1 to B6, B10 and B11 and an analog section with transistors T1 to T26 and IC's B7 to B9.

All operating data are applied in word-serial and bit-parallel form; this means the value for the frequency range and the three digits of the frequency are successively applied to the AF generator via the data bus, controlled by the address bus and AF strobe. The data bus ST26.19/.W/.20/.X and address bus ST26.V/.18 carry the data in positive logic. The following diagram explains the process of data entry. Example: Frequency set to 841 MHz. Input ST26.17, AF strobe, initiates the data transfer for frequency and frequency range when changing to L.



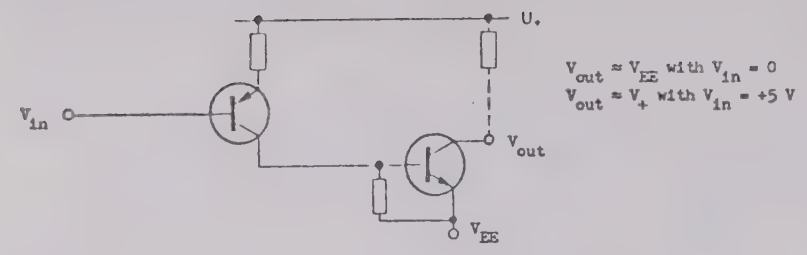
The heart of the AF generator subassembly is the IC B7 of type SE 566 T. This is a very precise, temperature-stabilized function generator, whose output frequency is mainly determined by the combination of two external passive components, namely a resistor and a capacitor:



R and C are frequency-determining

Schematic of SE 566 T

The capacitors C2 to C5 are individually used to determine the frequency ranges 10 - 100 Hz, 100 Hz - 1 kHz, 1 - 10 kHz or 10 - 100 kHz. Each capacitor can be taken to chassis potential by two junction FET's, e.g. T17 and T18, and thus be switched on. The FET's are connected in parallel, in order to obtain the lowest possible switch-on resistance, which is about 10 Ω in the present case. For example, to select the frequency range of 1 kHz, the BCD value B on the data bus goes to logic 1, corresponding to decimal 2, and on the address bus the BCD values A and B go to logic 1, corresponding to decimal 3, while the AF strobe goes to logic 0 (Low) for a short time. Thereby the data bus value decimal 2 is transferred to the data store B4 for the frequency ranges, which is activated by the address bus value decimal 3 via the decoder B1. A BCD figure corresponding to the selected frequency range is available at the store outputs pins 4 and 5 of B4; gates B10 and B11 convert this figure into the 1-out-of-4 code. The frequency-range capacitor C4 for the 1-kHz range is taken to chassis via the integrated FET switch driver B8 of type D 125 BK.



Circuit diagram of one of the six drivers in D 125 BK

Since the frequency calibration of the function generator SE 566 T is not equal throughout the frequency range of 10 Hz to 100 kHz, separate DC voltages must be applied for each frequency range to the FM input pin 5 of the function generator B5. For this purpose, the corresponding DC voltage, adjusted with potentiometers R38 to R41, is connected to the FM input of B7 together with the switching of the frequency-range capacitors. This DC voltage has a great effect on the waveform linearity at the triangular output of the function generator, pin 4, and thus on the distortion of the sinewave signal at the output of the subassembly.

Frequency can be set in three digits within each of the four frequency ranges. For example, in the 1-kHz range the AF generator can produce frequencies between 1 kHz and 9.99 kHz. When setting the frequency on the front panel, the operator need not take into account the frequency ranges. The required frequency is here always entered in kHz. The micro computer Y7 converts the information into the form appropriate to the AF generator.

Depending on the combination of range capacitor and frequency-value resistor switched on, the function generator B7 produces the corresponding frequency. The three-digit frequency data are conveyed to the function generator in the same way as the setting of the frequency range: For example, to produce the frequency 1.24 kHz, the three bits (4 for 40 Hz, 2 for 200 Hz and 1 for 1 kHz) are made available in this sequence and in serial form on the data bus. Calling up the address 0 for the LSB (least significant bit), 1 for the second bit and 2 for the MSB (most significant bit) the address bus conveys these data to the corresponding data stores B3 and B4 at the precise instant when the AF strobe goes to L. Gates B5 and B6 are drivers for the switching transistors T1 to T12.

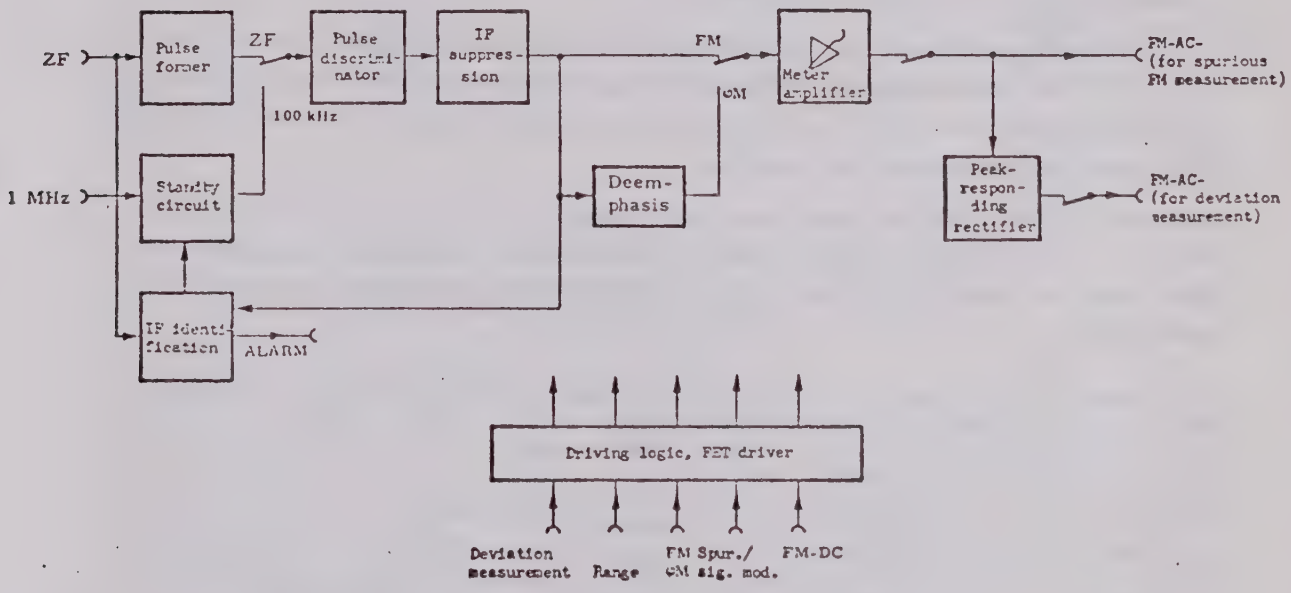
When all three bits for frequency setting have been set and the frequency range selected, the function generator B7 delivers a balance triangular signal with an rms level of 0.7 V $\pm$0.1 V at pin 4; this corresponds to $V_{pp} \approx 2.5$ V.

This signal is boosted in the operational amplifier B9 to the DC and AC values appropriate for the sinewave matrix (T25, T26, G1 3 to G1 16). The diodes G1 3 to G1 9 - Schottky diodes with low forward voltage and high switching speed - transform

the positive halfwave, diodes G1 10 to G1 16 the negative halfwave of the triangular signal into a sinewave. Resistors R63 to R68 and R89 to 94 round off any sharp corners of the polygonal curve approximating the sinewave. Potentiometer R55 is used to adjust the optimum triangle-signal level, potentiometer R57 the zero balance of the sinewave. G1 17 compensates for the temperature drift of T25 and T26. Potentiometers R85 and R104 serve for adjusting the distortion and R111 the output level of the AF generator (1 V_{rms}).

4.1.11 Deviation Meter Y12

See circuit diagram 240.0361 S



Block diagram

The 100-kHz IF coming from the prescaler and mixer is applied via a differentiating section (pulse former) at the input of the deviation meter to the Schmitt trigger B1I. The DC voltage corresponding to the IF (about 2 V) is applied to a IF identification circuit T1, B1II which determines whether the IF is in the permissible range (80 to 125 kHz). If not, the deviation meter is operated in standby with a fixed-frequency signal of 100 kHz which keeps the deviation meter in the steady state. Moreover the ALARM indicator is activated via ST28.$\overline{F}$.

When the deviation-meter mode is set (ST28.$\overline{D}$ = H) and if a sufficient IF signal appears, this signal is taken to the deviation meter which is already in its steady state. This makes for the short measuring time of 50 ms. The modulation signal is produced by the pulse discriminator B2II, B5, T2, T3 and the subsequent IF suppression stage.

The modulation signal at MP 2 is applied to the meter amplifier, either directly in the FM mode or via the deemphasis filter B7I, B7II in φ M.

The gain of the two-stage amplifier B11, B12 is switched according to the measurement range. V_{rms} = 0 to 2 V is available at the output MP 3. In spurious FM measurements this signal is applied to the input of the AF level meter.

In deviation measurements, the modulation signal is applied to a peak-responding rectifier, which delivers 2.83 V at MP 4 with f.s.d. This deviation-proportional DC signal is conveyed to the output amplifier of the AF level meter and then, after level conversion, to the A/D converter and meter J1.

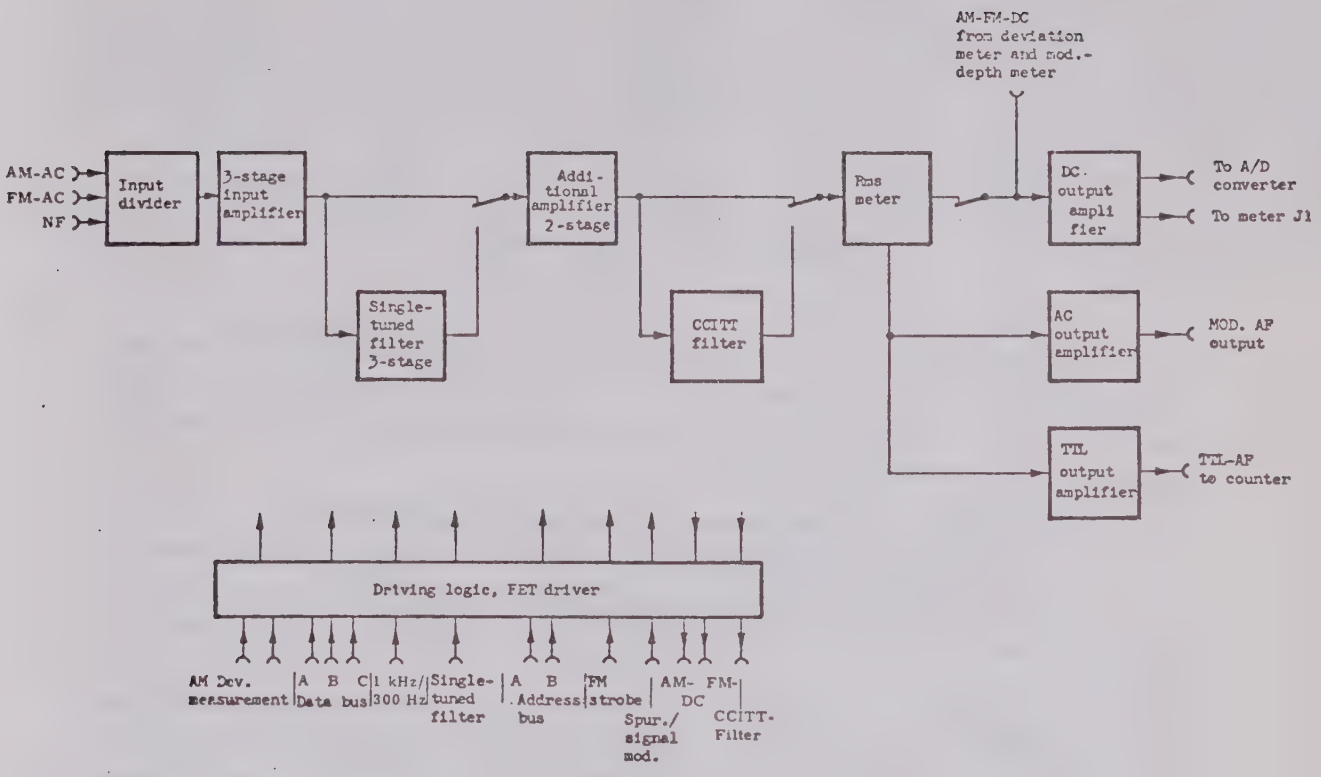
In spurious-FM measurements the meter amplifier provides an additional gain by the factor 100. The peak-responding rectifier is then not used; instead, the AC signal is applied directly to the FM-AC input of the AF level meter so that CCITT weighting and rms-responding measurements are possible.

The types of measurement and measurement ranges are controlled by means of a range decoder and FET drivers with FET switches. The following table shows the signal and logic levels at meter f.s.d., with 1 kHz modulation frequency and with spurious FM measurements.

MP 2 (AC)	B11 Pin 6 (AC)	MP 3 (AC)	MP 4 (DC)	FM-DC output (DC)	Meas. range		ST28 .28	.27	.$\bar{E}$	.X
≈80 mV	2 V	2 V	2.83 V	1 V	Signal modulation	5 kHz FM	H	H	L	L
≈320 mV	2 V	2 V	2.83 V	1 V		20 kHz FM	L	H	L	L
≈ 32 mV	2 V	2 V	2.83 V	1 V		2 rad φ M	H	H	H	L
≈ 80 mV	2 V	2 V	2.83 V	1 V		5 rad φ M	L	H	H	L
≈0.8 mV	20 mV	2 V	-	-	Spurious FM	50 Hz FM	H	L	L	H
≈3.2 mV	20 mV	2 V	-	-		20 Hz FM	L	L	L	H
-	20 mV	2 V	-	-		0.02 rad φ M	H	L	H	H
-	20 mV	2 V	-	-		0.05 rad φ M	L	L	H	H

4.1.12 AF Level Meter Y13

See circuit diagram 240.0432 S



Block diagram

The AF level meter is used in the AF measurements of rms value, frequency and distortion with or without CCITT weighting, and also in spurious-FM and spurious-AM measurements (inputs FM-AC, AM-AC). These are also possible with CCITT weighting. For the measurement of useful modulation only the test signal present at the AM-FM-DC input from the deviation meter or modulation meter is through-connected to the A/D converter and to the meter J1 via the output amplifier B10II.

All switching operations in the AF level meter are made electronically by field-effect transistors. The required control signals come from the function control, the A/D converter or the micro computer and are processed in a driving logic which activates the corresponding FET driver.

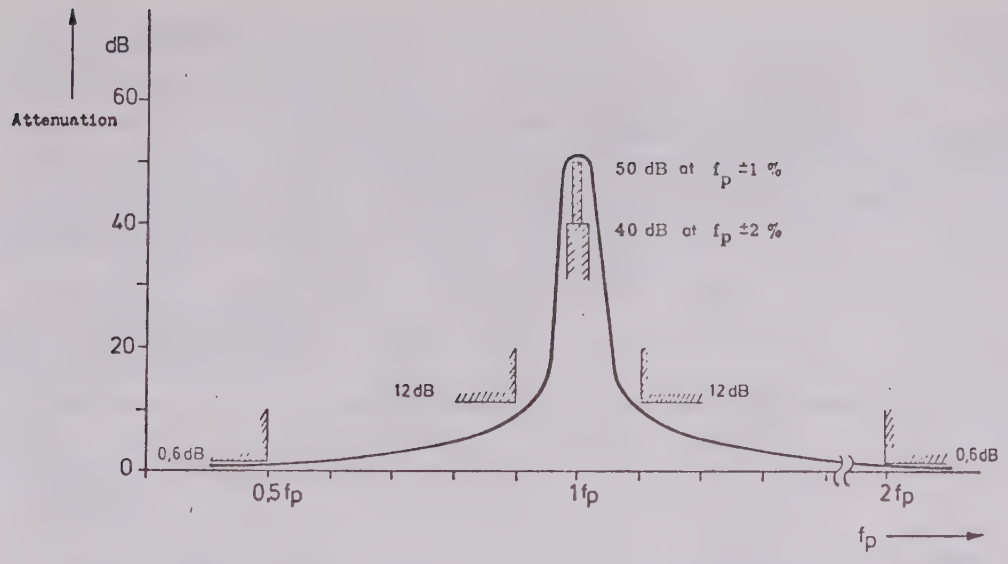
The AC input signals AF, AM-AC and FM-AC are brought to the operating level of 1 V at MP 1 with f.s.d. of meter J1, by means of two input attenuators and the 3-stage input amplifier B1II, B1I, B2I. The following table gives the signal levels and the logic levels for the control logic.

Input	Range	Voltage at B1, pin 5	Voltage at B1, pin 7	Voltage at B1, pin 1	MP 1	Mode from funct. control AM-MES. ST29 F	Mode from funct. control FM-MES. ST29 E	AF level range from A/C conv C,ST29.8	C,ST29.9	C,ST29.10	Through-connected FET's of input attenuator and amplifier
AM-AC	2 V	500 mV	500 mV	500 mV	1 V	H	L	X	X	X	T1, T3
FM-AC	2 V	500 mV	500 mV	500 mV	1 V	L	H	X	X	X	T2, T3
NF	3 mV	1,5mV	15 mV	150 mV	1 V	L	L	L	L	L	T4, T8, T10, T11
NF	10 mV	5mV	50 mV	500 mV	1 V	L	L	L	L	H	T4, T8, T10
NF	30 mV	15mV	150 mV	500 mV	1 V	L	L	L	H	L	T4, T8, T9
NF	100 mV	50 mV	500 mV	500 mV	1 V	L	L	L	H	H	T4, T8
NF	300 mV	150 mV	500 mV	500 mV	1 V	L	L	H	L	L	T4, T7
NF	1 V	500 mV	500 mV	500 mV	1 V	L	L	H	L	H	T4
NF	3 V	500 mV	500 mV	500 mV	1 V	L	L	H	H	L	T5
NF	10 V	500 mV	500 mV	500 mV	1 V	L	L	H	H	H	T6

At MP 1 the AF signal is distributed to a 3-stage switchable single-tuned filter and a voltage divider whose basic attenuation of 1 : 1.15 corresponds to that of the filter. Both signals are then applied to the input of the two-stage additional amplifier B6II, B6I according to the following table:

Control line	In AF measurement via voltage divider R67, R68	In distortion measurement via filter 300 Hz	In distortion measurement via filter 1000 Hz
Single-tuned filter ST29.28	L	H	H
1 kHz/300 Hz ST29.D	X	L	H

The single-tuned filter is composed of three stages; its pole frequency can be switched to 300 Hz or 1 kHz by the function control. The first filter stage, B3II, B3I operates with a Wien-Robinson bridge with feedback, which permits a high output level and is tuned to the selected pole frequency. The 1-kHz pole frequency is determined by C6-R29 and C7-R31-R32, the 300-Hz pole frequency by C6-R30 and C7-R31-R32-R33-R34. The pole frequency can be adjusted with R32 or R33, respectively. Bridge balance is made with R38. The second and third stages are identical R-C-L series resonant circuits with sharp cutoff. The inductance L is produced electronically by the gyrator circuit B4II and B4I or B5II and B5I, respectively. The following diagram shows the typical attenuation characteristic of the complete filter, normalized to the pole frequency f_p. The table gives the limit values for minimum and maximum attenuation.



Frequency	< fp/2 > 2 fp	fp/2 2 fp	0.9 fp 1.1 fp	0.98 fp 1.02 fp	fp
Attenuation	< 0.6 dB	≤ 0.6 dB	< 12 dB	≥ 40 dB	> 50 dB

The 2-stage additional amplifier B6II, B6I has a basic gain of 1.15 in AF measurement, thus providing the operating level of 1 V with f.s.d. at MP 4. In distortion measurements, the required additional gain is set by the micro computer so that the operating level of 1 V at f.s.d. is always available at MP 4. The following table gives the level plan for the signal and control levels in the different modes.

Mode	Range	Rms voltage at B6, pin 5	B6, pin 7	MP 4	Single-tuned filter ST29.20	Data bus A ST29.V	B ST29.18	C ST29.W	Address bus A ST29.17	B ST29.1	FM strobe ST29.6
AF measurement	0	870 mV	1 V	1 V	L	L	L	L	H	H	⎍
Distortion measurement	1	217 mV	250 mV	1 V	H	H	L	L	H	H	⎍
	2	87 mV	1 V	1 V	H	L	H	L	H	H	⎍
	3	21,7mV	250 mV	1 V	H	H	H	L	H	H	⎍
	4	8,7mV	100 mV	1 V	H	L	L	H	H	H	⎍

Following the additional amplifier, the signal is applied to an rms meter and a weighting filter complying with CCITT standard. The filter is passive and weights the signal - usually the spurious signal - according to the sensitivity of the human ear. The following table gives the logic levels for the different modes of operation with the weighting filter switched on and off.

Single-tuned filter ST29 28	Spur./sig. mod. ST29 26	AM meas. ST29 F	Deviation meas. ST29 F	AM-DC to mod. gen. ST29 X	FM-DC to deviation meter ST29 20	ST29 27	CCITT filter to Indicator ST29 5	Mode CCITT filter	Mode
X	X	L	L	H	H	H	H	ON	AF meas. weighted
X	X	L	L	H	H	L	L	OFF	AF meas. unweighted
X	H	X	X	H	H	H	H	ON	Spur.-mod. meas.
H	X	X	X	H	H	H	H	ON	weighted
X	H	X	X	H	H	L	L	OFF	Spur.-mod. meas.
H	X	X	X	H	H	L	L	OFF	unweighted
L	L	H	L	L	H	X	L	OFF	Sig.-mod. meas.
L	L	L	H	H	L	X	L	OFF	

The level converter B7, at the input of the rms meter B8, B9I, B9II, converts the operating level of 1 V to the test level of 3 V at MP 5 with f.s.d. and compensates for the basic attenuation of the CCITT filter. The rms value of the measured signal is determined according to the definition

$$V_{rms} = \sqrt{\frac{1}{T} \int u^2 \cdot dt}$$

B8 squares the input signal, R106-C20 integrate and the feedback via B9 extracts the root. The DC voltage resulting at MP 6 is then, except in signal-modulation measurements, applied to the DC output amplifier B10II, which feeds the A/D converter and meter J1. In signal-modulation measurements this output amplifier is directly driven by the deviation meter or modulation meter.

The AC output amplifier B10I and the TTL output amplifier B11 are driven from test point MP 5. The AC output amplifier B10I supplies a level of 1 V at f.s.d. in phase with the measured signal to the output socket BU6 MOD. AF on the SMPU front panel. The TTL output amplifier B11 is a comparator with hysteresis for noise suppression and delivers a TTL signal to the AF counter.

The driving logic consists of range and mode decoding (see level tables above) and of FET drivers driving the FET switches.

The following table gives the overall signal level plan for f.s.d. of the meter J1 with all available modes.

Test point	MP 1	MP 4	MP 5	MP 6	AM/FM-DC ST29 4	DC to A/C converter ST29 2	MOD/AF output ST29 H	TTL-AF ST29 E	DC to meter J1 ST29 B
Level	1 V AC	1 V AC	3 V DC	3 V DC	1 V DC	4.89 V DC	1 V AC	TTL level	1 mA DC

4.1.13 Modulation AF Control Y14

See circuit diagram 240.0603 S Bl. 1, 2

The modulation AF control converts the sinewave signal of precisely 1 V_{rms}, supplied either from the AF generator of the SMPU or from an external source, into calibrated AF voltages which are variable in steps. These voltages are applied to an amplitude modulator and/or a frequency modulator or to a power amplifier.

4.1.13.1 AM-AF Control

See circuit diagram 240.0603 S Bl. 2

Using digital programming, the AM-AF control derives from the internal or external AF voltage of 1 V_{rms} a modulation voltage corresponding to a modulation depth of 0% to 99% in 1% steps. The AM-AF control has 10 digital control inputs, two of which are used for the function control:

-AM ext., ST30.28
-AM-MOD., ST30.20

The function control operates with positive TTL logic, i.e. +5 V = logic 1 = on; if, for example, the input AM-Mod. ST30.20 is at +5 V, this means that amplitude modulation is desired. If AM-ext. is at 0 V, this means "not AM ext."; therefore, the internal AF generator is used as modulation voltage source.

The desired data are conveyed to the AM-AF control in word-serial and bit-parallel form via the four data bus lines ST30.17/.U/.18/.V. The data are coded in BCD positive logic. The address bus determines the addresses to which the data are applied successively. The data bus also operates with positive logic; it uses the PC-board inputs ST30.16/.T.

A complete routine, for example for AM-int., AM-mod., modulation 48% would be as follows:

AM-mod. (ST30.20) = +5 V
AM-ext. (ST30.28) = 0 V

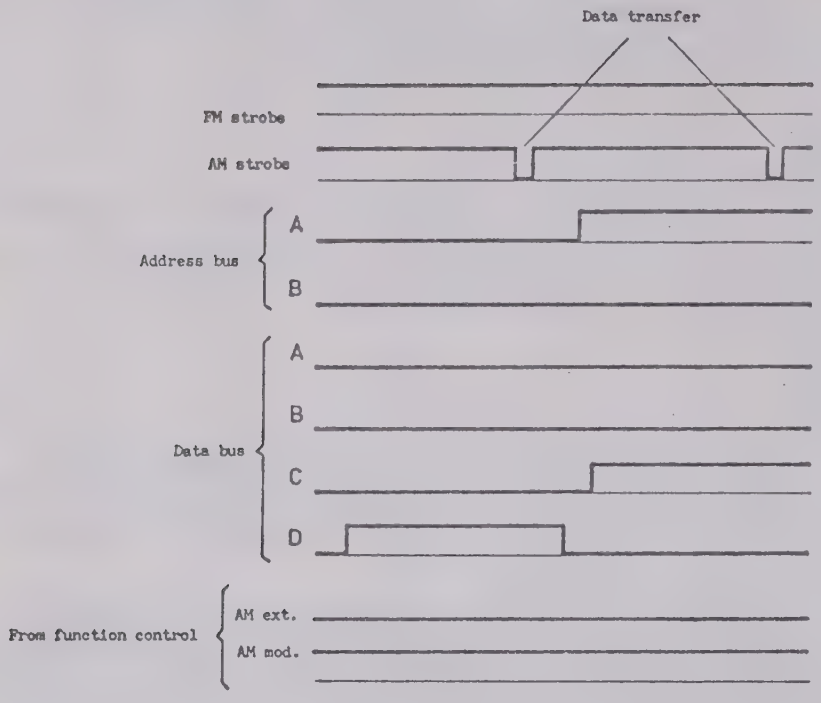
Data bus: D (ST30.V) = +5 V; A, B, C = 0 V (units position 8)

Address bus: A (ST30.16) = 0 V; B (ST30.T) = 0 V

If both address bus = decimal 0 and data bus = decimal 8 are set, the AM-strobe ST30.8 goes temporarily to 0 V,

FM-strobe ST30.J remains at +5 V.

In the same way the tens digit 4 is entered, as shown in the following diagram:



The information of the two strobe lines and of the address bus is combined by the decoder B19 and so processed that only one half of the 2 x 4 bit store B20 is activated in each case as listener for the data on the data bus.

The function control line AM-ext. selects the modulation voltage source, namely AM-ext. signal BU30.24, $\overline{B}$ or AM-int. signal BU30.25, $\overline{C}$. Either of the signals is passed on via the FET switch B37 and the operational amplifier B1. The integrated FET switch B37 includes p-channel junction FET's; if the voltage between gate and source (V_{GS}) = 0 V, the FET conducts, if V_{GS} = 5 V, the FET is cut off. The two source contacts of the FET's are internally combined and are at "virtual 0 V" since they are connected to the inverting input of the operational amplifier B1 of unity gain.

The third switching transistor in B37 is internally shorted between gate and source and thus conducts permanently. It compensates for the drain-source-ON resistance ($R_{DS\ ON}$). Only the difference of the ON resistances of the FET's is effective in this configuration. The diodes at the inputs of the FET's in B37 prevent the FET's that are cut off from being switched on by high positive signal levels; these levels are limited at +0.7 V so that no automatic switch-on can occur. G1 10 and G1 11 protect the subassembly from inadmissibly high external modulation voltages that may be applied by mistake.

The heart of the AM-AF control is the combination R29 to R36, B2, B3, B8, R99, B9, R104 to R107, B13 and R159. This is basically a programmable AF amplifier which is capable of producing 100 discrete AF level steps. The same circuit is used for the 10% and 1% steps of amplitude modulation. Depending on which combination of resistors R29 to R32 and R33 to R36 is switched on by B2 and B3, the AF level is set at the outputs 6 of the operational amplifiers B8 and B9. The FET switches B2 and B3 as well as B37 include p-channel junction FET's. The open-collector NAND gates B29 and B32 serve as drivers.

The gain-determining resistors R29 to R32 and R33 to R36 form the ratio 1 : 2 : 4 : 8 according to the binary code. When these resistors are appropriately combined, AF voltages with significance 0 to 9 are available at the outputs of B8 and B9. The summing amplifier B13 with resistors R106, R105, R107 adds up these values, the output voltage of B9 being reduced to 1/10 (R107/R105 = 0.1) since B9 is to correspond to the 1% modulation steps.

To set modulation depths below 10%, B20 passes on to B2 a decimal 0 in negative logic. This type of operation is not permissible for the operational amplifier B8 since thus its input 2 is almost completely open because of the high resistance of the FET switches. For this reason, B8 is isolated from the summing amplifier B13 by the FET switches T3 and T4. The corresponding criterion is supplied by B27 with decimal 0 on the 10% bus. The two drivers B33 drive T3 and T4 in push-pull:

at 10% = 0 T3 is cut off and T4 conducts ($R_{DS\ ON} \approx 20\ \Omega$)

at 10% = 0 T3 conducts and T4 is cut off.

(For the circuit diagram of B33, type D125 BK, see section 4.1.10.)

T3 and T4 are n-channel junction FET's; they are cut off at V_{GS} = -20 V and conduct at V_{GS} = 0 V.

A similar configuration, made up of B28III, B34, T5, T6, is at the output of the AM-AF control. The function control line AM-mod. ST30.20 separates or connects the AM-AF control output to the associated AM modulator input. Potentiometer R159 in the AM modulator is used to calibrate the modulation depth in conjunction with the AM modulator; the nominal value is 35.7 $mV_{rms}/\%$. From the output ST30.4, D the modulation voltage is taken to ST22 of the modulator Y16.

Since the built-in RF attenuator set of the SMPU can be set only in 1-dB steps, the AM modulator is used as an attenuator with 1% steps for the measurement of the squelch thresholds. Different DC voltages are applied for this purpose to the input AM-ext. signal ST30.24, $\overline{B}$ and to the input $V_{squelch}$ ST30.14, which have the following effect: If in the SQUELCH mode a modulation depth of 99% is set, the amplitude modulator delivers an RF voltage with a level corresponding to unmodulated operation. By adjusting the modulation depth it is possible to reduce this level in 1% steps down to the RF level of 0 V. Thus an attenuator covering 100 steps is available. Since the squelch thresholds are given in -dBV, the attenuation introduced by the setting of the AM-AF control must be converted into dBV by the micro computer Y7.

Double modulation is not possible with the above mode. The FM/φM-AF control accepts the degree of modulation, the digital value being entered in the associated store. With AM this means that modulation depth is entered in three digits into the stores for FM or φM (button 17 FM or φM). Direct connection from the FM/φM branch to the AM branch is ensured by T21 and T22. The signal from B14, corresponding to the modulation depth, is added to the DC voltage at B1 by R208 and R5. The nominal value of AM is adjusted with R5.

4.1.13.2 FM/φM-AF Control

See circuit diagram 240.0603 S Bl. 1

The FM/φM-AF control has three tasks:

- Setting the modulation voltage level for frequency modulation in 100-Hz deviation steps within a deviation range of 0 to 99.9 kHz (peak).
- Setting the modulation voltage level for phase modulation in 0.1-rad steps within a range of 0.1 rad to 10 rad.
- The FM-AF control is used as an AF attenuator; an AF voltage variable in 10-mV_{rms} steps in the range 0 to 6 V_{rms} (EMF across 50 Ω) is available at the AF signal output ST30.6, F.

The configuration of the FM/φM-AF control is in principle the same as that of the AM-AF control. The input level of the modulation AF must here also be 1 V_{rms} ±0.1%, present at ST30.25, $\overline{C}$ for FM/φM-int. AF signals or at ST30.23, $\overline{A}$ for FM/φM-ext. signals.

The modulation voltage source is selected by the signal present on the function control line FM-EXT. ST30.$\overline{F}$, where FM-EXT. = +5 V corresponds to an external source and FM-EXT. = 0 V to the internal AF generator. The data for frequency modulation (kHz in three digits), phase modulation (rad in three digits), and AF level (V in three digits) are entered into the data stores B21 and B22 by the same procedure as that employed with AM-AF control: The least significant bit (LSB) is entered through the data bus ST30.17/.U/.18/.V into store B22 with address decimal 0 from the address bus ST30.16.T and with the FM strobe at ST30.J. The process is repeated for the other bits of the data entry up to the most significant bit (MSB) of the entered value. It is to be noted that the data transfer into the stores B21, B22 is always activated by the FM strobe, independently of whether the values for phase modulation, frequency modulation or AF level are entered. This is possible because the three types of function exclude one another, i.e. they cannot be called up simultaneously.

The type of function is selected through three function control lines:

- Function control line INT. MOD. GEN. ST30.19: positive logic; +5 V = ON, 0 V = OFF. Through this line the FM/AF control is used for setting the AF level. The AF signal output ST30.6, F is taken to the front-panel socket AF 53 (Fig. 2-1).
- Function control line FM-Mod. ST30.X: positive logic. If this line is at +5 V, the modulation voltage for FM is available at the FM/ M signal output ST30.2, B.

- Function control line φM-mod. ST30.W: positive logic. If this line is at +5 V, the modulation voltage for φM is applied to the modulator via the FM/φM signal output ST30.2, B.

The individual circuits of the FM/φM-AF control will be described next: B29 is the driver for the FET switches B36, which select the external modulation voltage source or the internal AF generator.

The operational amplifier B7, which is protected against overvoltage by G1 12 and G1 13, connects the selected modulation voltage source to the input of the AF attenuator. This attenuator can be set in three decades:

	MSB	2.SB	LSB
FM	10 kHz	1 kHz	0.1 kHz
φM	10 rad	1 rad	0.1 rad
AF	1 V	0.1 V	0.01 V

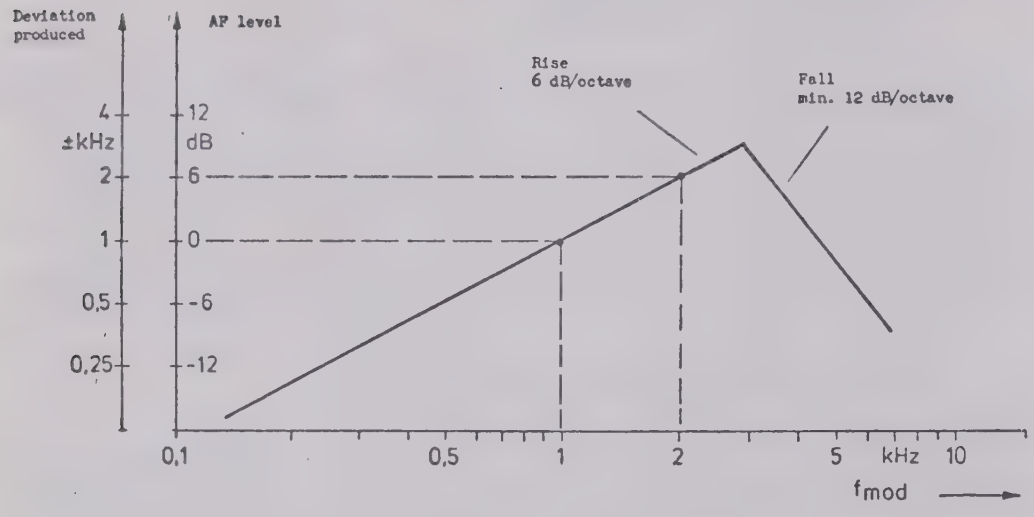
The individual decades consist of AF amplifiers programmable in BCD. Using high-precision switching resistors (e.g. R17 to R20 for MSB) with the ratio 1 : 2 : 4 : 8, AF levels with relative significances 0 to 9 can be set with the operational amplifier (B10 for MSB). The process is the same for all three decades. The set values are derived from the stores B21, B22 for all three types of function FM, φM, AF level and are applied via the drivers B30 and B31 to the integrated p-channel junction FET switches B4, B5, B6:

If a driver output is at 0 V, the connected FET conducts,
if a driver output is at +15 V, the corresponding FET is cut off.

If the set value for the first and/or second digit of the nominal data (FM, φM or AF level) is 0, the operational amplifiers B10 and B11 may tend to unwanted oscillations because of their almost open inverting input. To keep these oscillations safely from the modulator or from the AF output (front panel socket 53), the series-parallel switches T10 to T11 (MSB) and T12 to T13 (2nd SB) decouple these operational amplifiers from the subsequent circuits. B25 and B26 are used to identify the 0 state of the two data lines for the MSB and the 2nd SB and to give the switching command for the drivers B33. The individual decade values are combined with the correct significance (1/10/100) via the summing resistors R97, R91, R86 and passed on via the impedance transformer B14 to three signal paths:

- via R116, T14, B18 and T15 to the FM/φM signal output ST30.2, B. This path is opened when the function FM-mod. is selected by +5 V at ST30.X; T14 is rendered conductive by the driver B34, T15 conducts when FM-mod. or φM-mod. is activated.
- via R140, T7, B15, B35, R139 and C26 to the AF signal output ST30.6, F. The driver B34 renders the switching transistor T7 conductive when the function control line INT.-Mod.-GEN. ST30.19 is at +5 V. The operational amplifier B15 serves as driver for the power operational amplifier B35, whose output current is limited by R142 and R143, R139 determines the AF-generator source impedance of 50 Ω.

- via B16, T17, C17, B17, R119, T16, B18 and T15 to the FM/φM signal output ST30.2, B. In this preemphasis stage the AF signal, whose amplitude is frequency-independent, is given the form fixed for the phase modulation by C17, L1, R121. With a modulation frequency of 1 kHz the level of the modulation AF should be such that the modulator produces a deviation of ±1 kHz. This point (f_{mod} = 1 kHz, deviation = ±1 kHz) is defined for a level of 0 dB of the modulation AF.



AF level and deviation produced with φM complying with definition in radiotelephone systems, as a function of modulation frequency

T17 and T16 conduct via B34 with φM-mod. = 5 V; since T14 is cut off, the φM modulation voltage is applied via B18 to the FM/φM signal output ST30.2, B and from there to the modulator Y16. If neither frequency modulation nor phase modulation is selected - this condition is identified by the logic inhibition B28.I, II, IV - T15 is cut off and T18 conducts; the AF-FM input ST1 of the modulator thus has a well-defined chassis connection.

The whole signal path for FM is DC coupled. Thus it is possible to apply DC voltage via the front-panel socket FM 28 (Fig. 2-1). This DC voltage is processed in the modulation AF control for the FM mode FSK. In the normal case of frequency modulation with AC, a voltage of 1 V_{rms} ±0.1% must be applied for a deviation of 100 kHz. For modulation with DC this means a level of $\pm\sqrt{2}$ at the FM socket 28 .

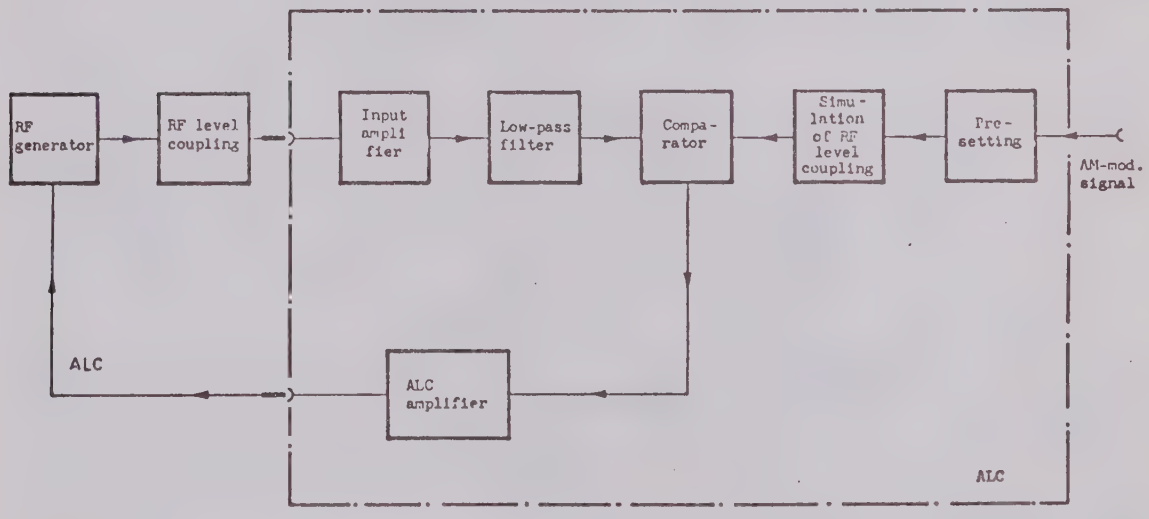
4.1.14 RF Overload Protection and ALC Y15

See circuit diagram 239.3619 S

RF overload protection

This circuit protects the attenuator set. If a higher RF power is fed to the RF socket BU10 of the SMPU while the SMPU is switched for receiver measurement, the attenuator set may be damaged. To prevent this, an RF probe is provided at the attenuator output. Its negative rectified voltage is conveyed via ST1 to the RF overload protection circuit. There a DC signal is derived from the rectified voltage by means of a low-pass filter. It is proportional to the RF voltage. This DC signal is amplified in B1I and applied to the threshold switch B1II. If the RF power at the attenuator input increases beyond 300 mW, the threshold switch responds and switches the RF switching board via the function control by L signal at BU70.4. Thereby BU10 is separated from the attenuator set and the dangerous RF power removed.

ALC



Block diagram

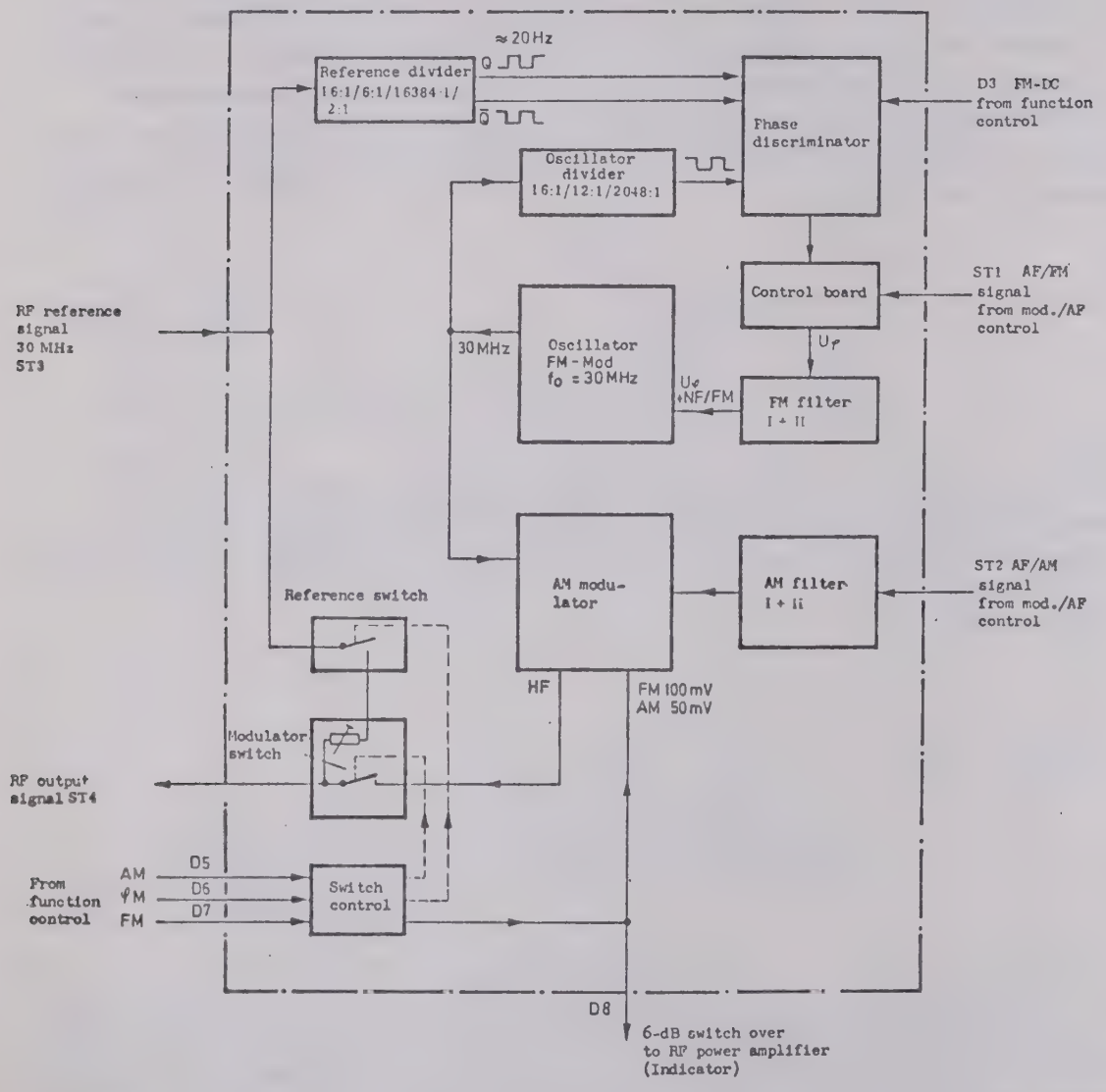
For ALC, the RF amplitude is coupled out at the attenuator input by peak-responding rectification. The resulting voltage is applied via ST2 to the input amplifier B2 with gain 4. A two-stage low-pass filter then removes any residual RF without affecting any AM which may be present. The voltage thus obtained is the actual value of the RF level being controlled.

The nominal value is preset in unmodulated operation by a DC voltage and in AM operation by an AF signal from the modulation/AF control Y14. This nominal-value signal at ST3 is conveyed to B4II and B4I, which simulate the RF level coupling. The comparator B3I forms from the actual value and the nominal value a control signal, which is applied to the

integral-action ALC amplifier B3II, B5. The ALC voltage for the RF generator of the Indicator is thus available at the output of the ALC amplifier.

4.1.15 Modulator Y16

4.1.15.1 General



The RF generator of the SMPU consists of a programmable decade synthesizer for the range 10 kHz to 500 MHz, a programmable RF attenuator set, an RF ALC amplifier and a modulator for AM and FM. The modulator has a fixed centre frequency of 30 MHz. To maintain the synthesizer accuracy in the case of modulation, the VCO in the modulator is synchronized with a 30-MHz reference frequency, which is derived from the synthesizer and therefore has the accuracy of the crystal. Synchronization is performed by means of a PLL circuit whose sampling frequency is very low to permit frequency modulation with a modulation frequency as low as 20 Hz. The PLL consists of a VCO, a phase discriminator with low-pass filter, a digital reference frequency divider and an oscillator divider (see block diagram above).

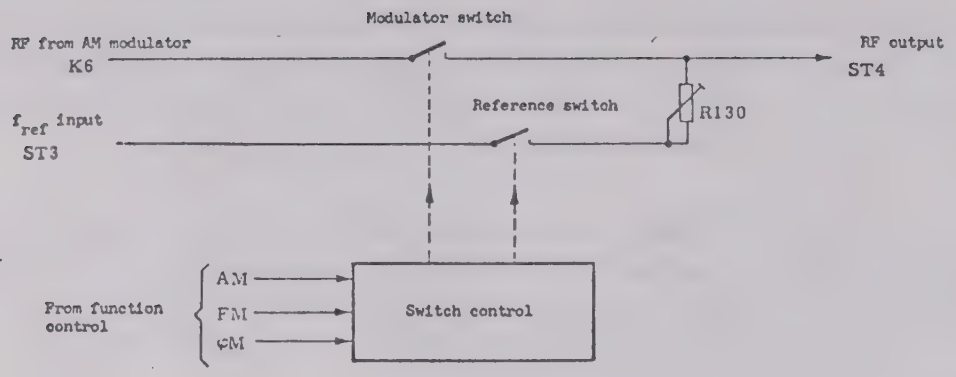
The modulation frequency is applied to the oscillator via the FM low-pass filter I and II. These filters have a cutoff frequency of 300 kHz. They prevent the RF of the oscillator from passing into other sections of the SMPU through the AF modulation path. Filter I is preceded by a control board, where the modulation voltage and the control voltage V from the phase discriminator are added.

For FM modulation with DC voltage, i.e. FSK, the synchronization must be switched off, since it would level out the "error" resulting from DC modulation. The phase discriminator is switched off for this purpose by the function control via BU80.7 FM-DC.

The 30-MHz carrier signal for the AM modulator, which may also be frequency-modulated, comes from the oscillator 239.6118.

Here again the AM low-pass filters I and II at the AF/AM input ST2 protect the following sub-assemblies of the SMPU from RF pickup of the 30-MHz frequency. With amplitude modulation, the AM modulator delivers an RF level of 50 mV_{rms} at a modulation depth of 0%, whereas with frequency modulation or phase modulation the AM modulator is so driven that it delivers an RF level of 100 mV_{rms}. This improves the S/N ratio with FM and φM.

The switch control 239.6647 recognizes whether one or more or none of the three types of modulation is to be put into operation. When the SMPU is required to deliver an unmodulated RF signal, the reference switch 239.6560 is connected through and the modulator switch 239.6601 cut off. If a modulated RF signal is required, the reference switch is cut off and the modulator switch conducts:



4.1.15.2 FM Modulation Section and Synchronization

See circuit diagram 239.5805 S

The FM modulation section and the circuit for the synchronization of the oscillator are closely related in their functions and are therefore described together. They comprise the following subassemblies:

- Oscillator, oscillator divider
- Reference divider, phase discriminator
- Control board, FM filters I and II

Oscillator 239.6118

This is a voltage-controlled oscillator with inductive feedback, comprising the extremely low-noise FET T1. The oscillator centre frequency is 30 MHz. The parallel resonant circuit is formed by L10, C23, the reactance diode G1 11 with variable coupling capacitor C22 and, in parallel, the linearizing diode G1 10 with its coupling capacitor C20. When only one reactance diode is used, the relation between the level of the modulation voltage and the deviation produced in the VCO is of necessity non-linear, since varactors have an approximately logarithmic characteristic. By parallel connection of two reactance diodes with different degrees of coupling to the main resonant circuit, but working at the same operating point and driven with the same modulation voltage, the voltage/deviation characteristic can be linearized. Modulation distortion is kept below 0.5% up to a maximum deviation of $\pm$100 kHz through this linearization.

Potentiometer R20 is used to adjust the operating point of the oscillator transistor T1; to provide for optimum transient response and minimum RF distortion, the RF output level is adjusted to 20% below maximum by means of R20. Coil L10 has a variable ferrite core, which permits the oscillator centre frequency to be fixed largely independent of the deviation characteristic. The 10-turn Johnson trimmer C22 and potentiometer R14 for the

operating point of the reactance diode are alternately used to adjust for optimum modulation distortion. C22 also permits correction of the deviation characteristic.

The nominal modulation voltage is 1.8 V_{rms} for ±100 kHz deviation, corresponding to a DC voltage of ±2.5 V for ±100 kHz deviation. In addition to the modulation voltage for FM, the control voltage Vφ from the phase discriminator is applied to the oscillator at point 10 of the oscillator board. This DC voltage compensates for the slight temperature drift of the oscillator, keeping the oscillator frequency at 30 MHz with crystal accuracy. The synchronization range is 30 MHz ±25 kHz.

The RF signal produced by the oscillator is passed on to the AM modulator and also to the oscillator divider.

Oscillator divider 239.6182

The oscillator synchronization uses the very low sampling frequency of slightly more than 9 Hz, to make frequency modulation with very low frequencies possible. This sampling frequency is derived from the 30-MHz reference signal by digital division. For comparison of the phase of the reference signal and that of the oscillator signal being controlled, the oscillator signal must also be divided by the oscillator divider.

The RF differential amplifier B5 boosts the oscillator RF signal so that it can be handled by the digital TTL counter B6. B6 and B7 divide the 30-MHz signal by 16 and by 12. The digital counter B8 of complementary MOS transistor design (CMOS) divides the frequency by 2048. The overall ratio of the oscillator divider is thus 393216 : 1 so that the output frequency is about 75 Hz. This squarewave signal is applied to the phase discriminator, which compares the phase of the divided oscillator frequency with that of the divided reference frequency.

Reference divider 239.6830

From point 30 of the circuit board the 30-MHz RF reference signal is applied with a level of about 130 mV_{rms} to the RF differential amplifier B10. After transformation the signal is divided by 16 in B11, by 6 in B12, by 16384 in B13 and by 2 in B14. Complementary squarewave signals of a frequency slightly above 9 Hz are thus available at pins 6 and 8 of B14. The CMOS divider CM 4020 cannot directly drive TTL gates. Transistor T5 is therefore inserted between B13 and B14 for impedance transformation. The complementary TTL squarewave voltages from B14 are shifted in level and in centre voltage by transistors T6 and T7; the 0-to-5 V squarewaves become squarewave signals of -15 to +6 V. These are used to sample the phase of the oscillator signal in the phase discriminator.

Phase discriminator 239.6260

The phase discriminator compares the phases of the frequencies from the reference divider and from the oscillator divider.

Phase comparison is possible, in contrast to frequency comparison, between different frequencies as long as the ratio of their nominal values is an integer.

The ratio is here

$$\frac{\text{oscillator divider frequency}}{\text{reference divider frequency}} = \frac{8}{1}$$

T10 brings the oscillator divider signal to TTL level and passes it on to the monostable B20, which forms very steep pulses of short and very stable duration. T11 conducts during the short pulse time t_1 and charges C52 to about 14 V. During the cut-off time t_2 of T11, C52 discharges via the parallel resistor R65.

The resulting sawtooth (see 239.5805 S) has an amplitude of about 6 V_{pp} and is applied via C53 to the first sampling transistor T13. The sampling transistors T13 and T15 are controlled by the complementary squarewaves from the reference divider, meaning that they are switched in phase opposition and conduct alternately during a half-cycle of the reference divider frequency.

Assuming that first T13 conducts, the full sawtooth voltage is applied to the charging capacitor C54. If T13 is cut off, the voltage present at C54 at the instant of cutoff is maintained and is conveyed to C55 and C56 via the impedance transformer T14 and via switch T15 which conducts during this period. T13 does not conduct until T15 is cut off; this results from the above-mentioned control in phase opposition of the sampling transistors T13 and T15. The phase-proportional voltage produced by the sampling process is available at the output of the impedance transformer T16.

If the oscillator frequency and reference frequency are equal, the reference divider frequency samples always the same point of the sawtooth determined by the oscillator divider frequency; this point corresponds to a particular phase difference between the signals being compared. This has led to the designation phase locked loop (PLL).

If synchronization is not possible, e.g. if the oscillator is too far off tune, an AC voltage appears at the output of the sampling circuit. This voltage is the result of the sawtooth ramp being sampled.

The impedance transformer T16 is followed by a non-linear low-pass filter consisting of the RC section R78 + R87/C57 and the diodes G1 20 and G1 21. The non-linearity of the filter consists in the fact that the filter output voltage rapidly follows large jumps of the control voltage V and thus rapidly counteracts the abrupt frequency error of the oscillator (for example when the SMPU is switched on); in the normal case, when only the slow temperature drift of the oscillator is levelled out, the filter has a high time constant. The non-linear filter behaviour is realized by the fact that either of the diodes G1 20 or G1 21 conducts upon a large variation of the control voltage, thus bypassing the high-valued resistor R87 and reducing the time constant to about one tenth. V is applied to the control board via the impedance transformer T17.

The phase discriminator is switched off in the FM-DC mode. This is performed by the function control line FM-DC at BU80.7. 0 V on this line corresponds to synchronization, +5 V to FM-DC. If +5 V is present at pin 4 of B20, the monostable B20 can no longer form pulses from the oscillator divider frequency. This means that a DC voltage

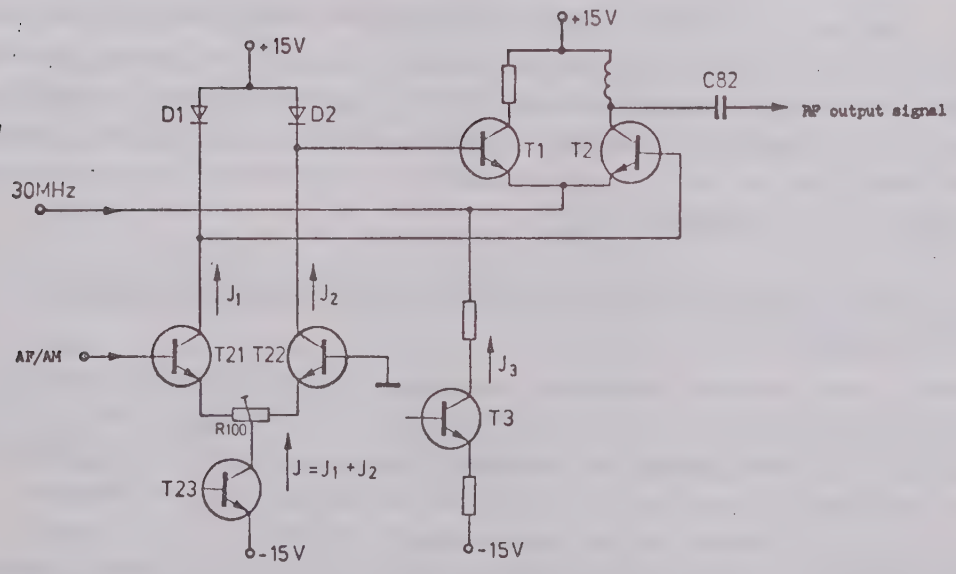
appears at the centre tap of potentiometer R86, i.e. at the input of the first sampling transistor T13. This DC voltage depends only on the position of the tap of R86. To establish uniquely defined conditions, potentiometer R86 should be so adjusted in the FM-DC mode that with the AF/FM input ST1 shorted, exactly 0 V is present at point 10 of the oscillator board. Then the exact centre frequency of 30 MHz should be adjusted with L10. Thus it is ensured that with synchronization the capture range is equal in both directions.

Control board 239.6376

The control board fulfils three tasks:

- Reducing the control voltage amplitude V by means of the divider R1, R10 (R10 in the oscillator) to a value corresponding to a capture range of ±25 kHz.
- Reducing the FM-AF voltage of 4 V_{rms}/100 kHz to about 1.8 V_{rms}/100 kHz. Adjustment with R2.
- Adding the modulation voltage AF/FM and the control voltage V , and conveying the sum signal to the modulation input of the oscillator via the FM filters I and II.

4.1.15.3 AM Modulator 239.6901



Schematic of AM modulator

Transistor T23 is a constant-current source delivering the current J, which is distributed to T21 and T22 such that always J1 + J2 = J. The magnitude of the partial currents depends on the voltage applied to the base of T21. Diodes D1 and D2 (these designations apply only to the above schematic) distort the voltages applied from T21 and T22. The two predistorted voltages are applied to the differential amplifiers T1, T2. The combined emitters are driven with the 30-MHz oscillator signal. The differential amplifier which is driven in phase opposition by the predistorted AF voltage shapes the 30-MHz signal in the rhythm of the AF voltage; the result is an amplitude-modulated signal.

The predistortion by diodes D1 and D2 counteracts the distortion which otherwise would be caused by the base-emitter junctions of T1 and T2.

For the further description of the AM modulator refer to circuit diagram 239.5805 S. At point 54 the oscillator signal has a level of 1.6 to 2 V_{pp}. The signal is attenuated by R90 to make sure that about 100 mV_{rms} is present at C70. T20 isolates the oscillator from the amplitude modulator. The diodes D1 and D2 shown in the schematic above are formed by shorting the base-collector junctions of two individual transistors of the IC B25. Thus the predistortion diodes and the modulation transistors have the same temperature and with high probability also the same current/voltage characteristic since they are made from the same chip.

Potentiometer R100 is used to adjust the AM modulation distortion. The AF/AM voltage at the base of T21 is about 35.7 mV_{rms} per % modulation depth. T24 isolates the AM modulator from the subsequent subassemblies.

Different standard levels exist at the output 48 of the AM modulator, depending on the type of modulation.

In the AM mode the switch control 239.6647 applies -12 V to point 80 of the AM modulator. As a result, Gl 23 is cut off and the base of T22 is taken to chassis via R102. The output level of the AM modulator is then 50 mV_{rms} at 0% modulation. In the FM and φM modes, +12 V is present at point 80. T22 is thus driven to higher output, resulting in an RF output level of 100 mV_{rms}. This higher level improves the S/N ratio of the SMPU output signal in FM and φM by 6 dB.

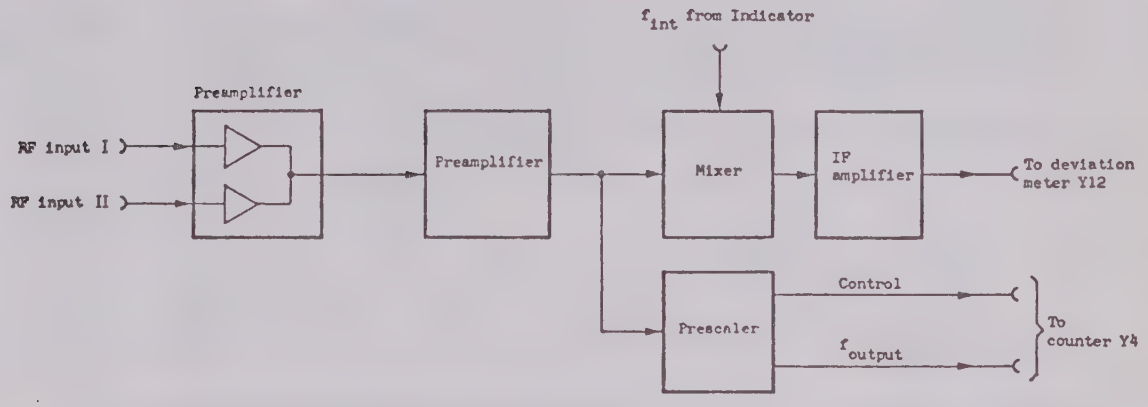
4.1.15.4 Switch Control 239.6647, Modulator Switch 239.6601 and Reference Switch 239.6560

The switch control recognizes whether at least one of the three possible types of modulation has been selected. If so, +12 V is applied to the modulator switch via point 72. This positive voltage causes the diodes Gl 25 and Gl 27 to conduct and cuts Gl 26 off. The modulated RF signal is connected through to the RF output ST4. Moreover, a voltage of -12 V is applied from the switch control via point 71 to the reference switch. Diodes Gl 30, Gl 32 and Gl 34 are cut off, Gl 31 and Gl 33 conduct. Therefore the reference frequency does not reach the RF output of the modulator. If no modulation is required, the switches are controlled in the opposite sense. The reference frequency is conveyed via R130 to the RF output ST4. Since the RF output level must be equal when the modulation is cut on or off, the reference frequency signal is adjusted accordingly

with R130. With AM modulation, the operational amplifier B32 delivers the -12-V switching signal for the AM modulator and, moreover, the same switching voltage for the 6-dB switchover in the RF power amplifier.

4.1.16 Prescaler and Mixer Y20

See circuit diagram 239.7314 S



Block diagram

Preamplifier I is used to convey the signals from the two RF inputs BU10 and BU11 to preamplifier II. Preamplifier I consists of two identical stages, T63 and T64, whose outputs are connected together. Preamplifier II consists of the five stages T1 to T5; it is protected against overloading and has a limiting effect.

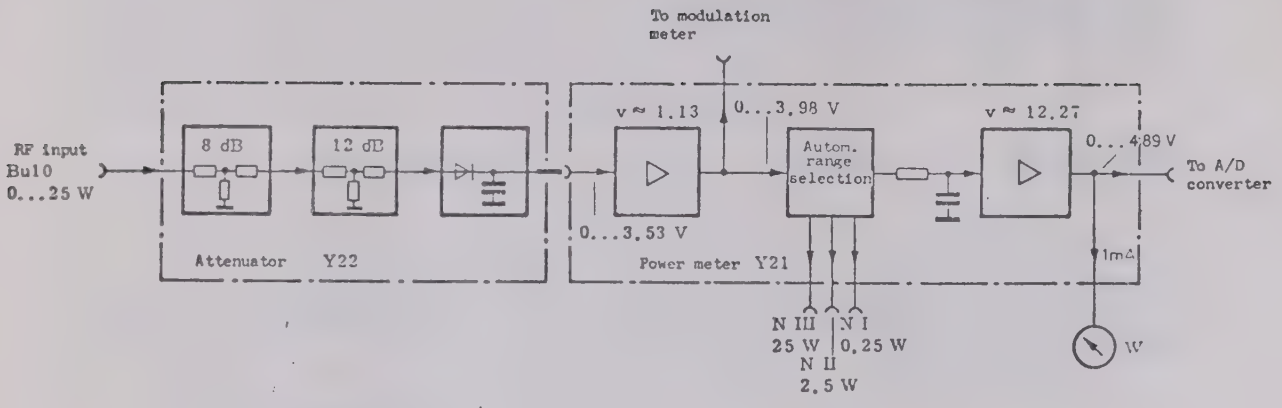
The subsequent mixer produces, with the aid of the computer-controlled conversion frequency f_{int}, an IF of 100 kHz. The IF amplifier separates this IF from the other conversion products, amplifies and limits it. The output to the deviation meter thus has TTL signal.

The prescaler is also fed from the output of preamplifier II. The frequency range identification B67, which also controls the gate time of the counter, connects to the counter output ST42 either the undivided signal path at input frequencies < 65 MHz or the prescaler output at input frequencies > 65 MHz. The prescaler proper consists of the ECL dividers B63, B64 and B65 and divides by 8.

Input frequency	Frequency range identification Gate time control (D28)	Division ratio Output freq./input freq.
< 65 MHz	L	1 : 1
> 65 MHz	H	1 : 8

4.1.17 Power Meter Y21

See circuit diagram 239.8510 S



Block diagram

The RF input signal at the front panel socket BU10 is attenuated in Y22 by 20 dB (25-W model) or 23 dB (50-W model). The peak-responding rectifier produces a negative voltage of 0 to 3.53 V which is applied to the input circuit of the RF level meter. The temperature-dependent forward voltage of the meter diode is eliminated by a compensation diode.

The input circuit including B1 has a gain of about 1.13 (depending on adjustment) so that 0 to 3.98 V is available at the output MP 1. Since this signal is also amplitude-modulated, it is passed on to the modulation meter Y11. It is also applied to the automatic range selection B2 to B5, which limits the signal to 0 to 0.398 V and at the same time activates one of the control lines for the ranges 0.25/2.5/25 W or 0.5/5/50 W by active-Low signal.

The automatic range selection is followed by the integrating section R30, C5 which eliminates amplitude modulation. Then follows the output amplifier B6 with gain 12.27. Thus 0 to 4.89 V is available at MP 2 for the A/D converter and for the meter J2 (1 mA for f.s.d.). The following table gives the levels for f.s.d. of the meter.

Range	MP 1	MP 2	Meter J2	Range outputs BU35 .H N I	.F N II	.E N III
25 (50) W	3.53 V	4.89 V	1 mA (f.s.d.)	H	H	L
2.5 (5) W	1.12 V	4.89 V	1 mA (f.s.d.)	H	L	H
0.25 (0.5) W	353 mV	4.89 V	1 mA (f.s.d.)	L	H	H

The control line at contact 8 can switch off the power meter for RF by means of -20 V, for analyzer measurements. The control line "RF count" at contact K can switch off the result output of the power meter. (Both control lines are omitted in the block diagram).

The output voltage at MP 2 is proportional to the average RF peak voltage across 50 Ω. On customer's request, the power meter can be equipped with a squaring circuit which delivers a voltage proportional to the power to the A/D converter.

4.1.18 RF Switching Board

See circuit diagram 239.1000 S Bl. 1

The purpose of the RF switching board is routing, switching and attenuating the RF input and output signals of the SMPU Control Unit. The board contains the attenuator set Y25 (complies with the Programmable Attenuator Set Type DPVP but has no 1/10-dB steps). In addition, a 50 W/3 dB attenuator, a 25 W/8 dB attenuator Y221 and a measuring head and RF distributor Y222 are provided. The RF relay contacts rs1, rs2, rs3 and a set of cables connect the individual subassemblies to one another and to the input and output sockets. The various connection possibilities can be seen in the circuit diagram 239.1000 S Bl. 1.

The following table shows for the four operating modes, which of the outputs, NO or NC, are connected to the COM inputs of the RF relays. When the SMPU is switched off, the input COM of contact rs1 is connected to NC to protect the attenuator set.

Mode	rs 1 COM connected to:	rs 2	rs 3
Transmitter test	NC	NO	NC
Duplexer test	NC	NO	NC
Analyzer	NC	NO	NO
Receiver test	NO	NC	NC

5. Repair

5.1 Required Instruments and Accessories

No.	○ Equipment, required data ● Recommended R&S type	Type	Order No.	Use in section
1	○ Digital voltmeter 5 digits, error < 0.1%			5.2.1 5.2.11 to 5.2.15
	● Digital Multimeter 40 Hz - 20 kHz 100 µV - 1000 V Error 0.04% of rdg.	UGD 51	234.05.....	
2	○ RF millivoltmeter			5.2.15
	● RF-DC Millivoltmeter with 50-Ω Insertion Head 1 kHz - 1.6 GHz AC: 2 mV - 10 (300) V DC: 1 mV - 1000 V	URV -	100.0130.02 243.9418.54	
3	○ VHF-UHF test receiver			5.2.9
	● VHF-UHF Test Receiver with RF Unit 25 - 230 MHz RF Unit 160 - 470 MHz RF Unit 460 - 900 MHz RF Unit 850 - 1300 MHz	ESU - - - -	100.1143.02 100.1189.02 100.1195.02 100.1208.02 100.1214.02	
4	○ Frequency counter up to 500 MHz			5.2.10 5.2.15
	● Frequency Counter Basic Unit Plug-in 10 - 800 MHz or Frequency Controller for Signal Generators SMDF and SMDA with Counter Adapter	FET 2 - -	 100.6039.02 100.6080.02 100.8131.02	
5	○ Oscilloscope Bandwidth 0 - 90 MHz dual-beam			5.2.10 5.2.13
	● Oscilloscope of series 7000 by Tektronix			
6	○ Power meter 10 kHz - 500 MHz			5.2.14 5.2.16
	● Microwave Power Meter with 50-Ω probe 0 - 15 GHz 0.1 - 330 mW	NRS	100.2433.92 100.2440.50	
7	○ Power signal generator			5.2.15 5.2.16
	● Power Signal Generator max. 2 W (50 Ω)	SMLU	200.1009.02	
8	○ Logic analyzer			5.2...

No.	O Equipment, required data ● Recommended R&S type	Type	Order No.	Use in section
9	O Logic tester for IC's ● Logicscope 16-pole	IFP	228.0036.90	
10	O Listener and talker complying with IEC ● Desk-top Calculator TEK 31 (Tektronix) with IEC Interface	SMPU-Z2	240.3902.02	5.2.3 5.2.4 5.2.5 5.2.6
11	O Attenuator set 0 - 100 dB ● Programmable Attenuator Set 0 - 139.9 dB	DPVP	214.8017.52	5.2.9
12	O Distortion meter for 300 Hz, 1 kHz e.g. EHD 50 by LEA			5.2.10 5.2.12 5.2.15
13	O RF signal generator FM, φ M ● Universal Signal Generator .15 Hz - 525 MHz with frequency meter	SMDU	249.3011.04	5.2.11 5.2.14
14	O AF generator 300 Hz/1 kHz see No. 13 ● Modulation meter e.g. AFM 2 by Radiometer			5.2.11 5.2.13 5.2.15

5.2 Adjustment and Fault Location

5.2.1 Stabilizer Y1

See circuit diagram 239.1000 S Bl. 3

The specified voltages refer to operation with nominal AC supply voltage. The output voltages of the stabilizer should be adjusted with the aid of a digital voltmeter (e.g. UGD 51) to an accuracy of $< 0.5\%$.

The -20-V stabilizing circuit is adjusted to -20 V $\pm 5\%$ (contact 84 on motherboard).

The positive and negative switching voltages for the motors of the attenuator set are dynamically through-connected; they have fixed values of ± 15 V $\pm 5\%$ and ± 10 V $\pm 5\%$.

Adjust the +5-V supply voltage of the TTL circuits with R71 to 5 V $\pm 1\%$ at full load (DC voltage between chassis and contact 83 of motherboard). R71 is on the cooling fin of the rear panel.

Adjust DC voltage between chassis and
contact .81 with R52 to +15 V ±0.5%,
contact 82 with R56 to -15 V ±0.5%,
contact 125 with R63 to -10 V ±0.5%.

Adjust the pulse widths of the staircase supply voltage for the motors of the attenuator set using the trimming potentiometers R82 and R83.

Adjust R82 such that the voltage is 15 V for 4 ms. Adjust the overall pulse width to 35 ms using R83.

5.2.2 Input Units

See circuit diagrams 239.4380 S (Y2 in Control Unit) and 41105/2-3 S (Y24 in Indicator)

The address of the corresponding buttons of the Indicator and of the Control Unit can be checked at contacts 1 to 8 of the input unit Y2 in the Control Unit. It must correspond to the address given in Table 5-2.

Input unit Y2 (Control Unit)

The output information of the keyboard 22 (Fig. 2-1) can be checked at contacts 11 to 14. The figures are made available in negative BCD code with a control signal (figure strobe).

The electronic variation Y29 must produce, during rotation, two signals displaced about 90°. Depending on the direction of rotation these signals must produce pulses at the respective monostable, B5I or B5II.

Input unit Y24 (Indicator)

The address lines A to H can also be checked at contacts 1 to 8 of the input unit Y2 in the Control Unit.

In addition to the address lines A to H, the input unit Y24 contains data lines for inputting and outputting the level range and for outputting the variation addresses. The data lines carry binary information in parallel form. Only lines A, B and C need therefore be checked for fault location. This means with respect to the level range that line A is active for the 10-mV range, line B for the 30-mV range and line C for the 300 mV range. The same applies to the 1-kHz, 100-kHz and AF variation for the outputting of the variation addresses (see table below).

The variation buttons must light according to the button which has been depressed.

	Variation address		
	A	B	C
1 kHz	H		
100 kHz		H	
AF var.			H

	Input and output of AF level range		
	A	B	C
10 mV	H		
30 mV		H	
300 mV			H

Check the entry and indication of the AF level ranges with the SMPU set for receiver test.

5.2.3 Function Control Y3

See circuit diagram 239.2812 S

The function control subassembly has no adjusting elements. If a fault occurs, first the clock generator should be checked at MP 2. Its frequency is about 40 kHz.

The initial address of a setting can be checked at check points 11 to 18. Fault location can be facilitated by connecting the check points 11 to 12 via 8 switches to a clock generator (f ≈ 1 kHz) with TTL level. The initial addresses (see Table 5-2) are set with the switches. If the entry is inhibited by a permanent BUSY signal, the bridge between points 1 and 2 must be removed.

The performance of the function control should be checked at the remaining check points. The pulse diagram is shown in section 4.1.3.

A data entry is recognized at MP 1. The loading and reset pulse synchronized with the clock generator is available at MP 6. This pulse must be present, inverted, at ST32.D and signal data acceptance to the data coupler Y5.

The count pulse for the address counters B5 and B6 is present at MP 7. It corresponds to the inverted pulse of the clock generator and is inhibited with the MSB of the ROM at MP 9.

In the off state MP 9 is at logic H. The word read out is released with L state of the pulse at MP 5.

On arrival of a jump command, the data word of B8 is stored with the loading pulse at MP 4. Thus MP 3 goes to L state, inhibiting B47II/III and releasing the counter until zero is reached.

The signal from MP 8 signals the readout of the ROM B7 to the BUSY combination of B48III. After readout the signal turns H.

5.2.4 Data Coupler Y5

See circuit diagram 239.9930 S

The data coupler has no adjusting elements. Manual operation must be ensured before a fault location is undertaken.

The trigger signal for all programming commands is the falling edge of the DAV signal.

First check the setting of the address. Set ATN to Low and the data bus D0 to D6 to the data word of B6. The listener and talker addresses differ in the bits of D5 and D6. The address set is displayed with G1 1 and G1 2. The talker address and the listener address must cancel one another. The address is cancelled with the ASCII signals given in Table 4-2.

For checking the other programming commands, the SMPU must be addressed as listener and ATN must be at High. When the following signals are entered, the logic state specified must appear at the outputs:

Column of ASCII table	Programming command	Contact	Log. state
0	SDC (Selected Device Clear)	ST22.F	L
1	DCL (Device Clear)	ST22.F	L
2	AF level range	ST22.K	L
2	Decimal point	B18, pin 12	L } St22.26 = L
3	Figure 0 - 9	B4, pin 9	L }
4	1st programming word	B14, pin 6	H
5	2nd programming word	B14, pin 2	H and
		Data D0 to D3 at St22.$\bar{E}/\bar{F}/\bar{D}/\bar{C}$	

The handshake is to be checked dynamically. The function control Y3 and micro computer Y7 must be in functional order. The corresponding pulse diagram is shown in section 4.1.5. The interval between the falling edge of the DAV pulse and the rising edge of the DAC signal is 50 to 60 µs for the commands of columns 3 and 5 and about 200 ns for the remaining commands of columns 0, 1, 2 and 4.

With the commands SDC, DCL, the level ranges and the characters of column 4 (② to 0), signal RFD follows DAV.

The figure entry including the decimal point causes a delay of RFD with respect to DAC of about 40 ms. The delay of the entry of a word of group 5 depends on the program entered.

Check the data output first statically with the talker address set (ST22.M). The output test-CPU supplies the sampling of the DAC and RFD conditions to the computer. With RFD = H the computer delivers the DAV signal via ST22.7. With DAC = H (while DAV = L) the computer cancels DAV and applies the new data word to the internal data bus.

The dynamic check is made with a controller (e.g. Desk-top Calculator TEK 31 and Interface SMPU-Z2 240.3902.02) and a logic analyzer. The handshake should comply with the pulse diagram of section 4.1.5.

5.2.5 Analog/Digital Converter Y6

See circuit diagram 239.9898 S

Fault location

All data lines in the A/D converter are of binary design. For fault location it is therefore sufficient to enter the data 1-2-4-8.

The function of the A/D converter B14 is checked when the A/D conversion is started (address 8 on the address bus) with a repetition frequency of < 50 kHz and the parallel outputs are traced.

Adjustment

The offset voltage and the gain of the A/D converter B14 and of the meter amplifier B18 are to be adjusted. The digital value of a voltage at the ADC socket is sampled and indicated in a programming loop via the programming plug data J/0. With a voltage of 2.5 mV at MP1, adjust the zero point with R26 so that the digital value goes from 1 to 0.

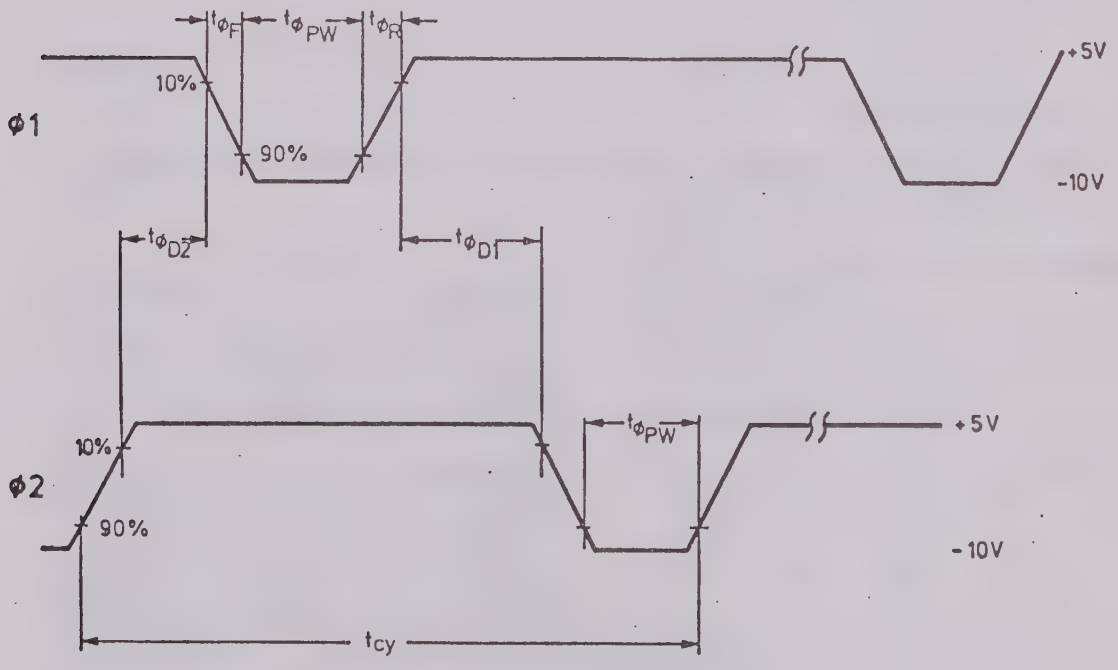
Gain is adjusted with R25: With a voltage of 4.993 V at MP1, vary R25 until the digital value changes from 1022 to 1023. The meter amplifier B18 is adjusted to zero offset with R42 (short-circuit between inner and outer conductors of BU16). Adjust the nominal gain with R40 ($A_1 = 10^5/R37$; $A_2 = 10^5/R38$).

5.2.6 Micro Computer Y7

Adjusting the two-phase clock generator

The phase shift between ϕ1 and ϕ2 is produced by the monostables B21 and B22. Clock frequency, pulse duration and time relation of the pulses are adjusted with R20, R22, R29 and R31. A dual-beam oscilloscope is required for measurement. ϕ1 is to be measured at MP 1 and ϕ2 at MP 2.

The following time diagram shows the correct adjustment.



Tolerances:

t_{cy}	= 1.35 µs	1.35 µs	1.55 µs	Clock period
$t\phi_{PW}$	= 420 ns	380 ns	480 ns	Clock width
$t\phi_{D1}$	= 475 ns	300 ns	550 ns	Clock delay 1
$t\phi_{D2}$	= 150 ns	150 ns	250 ns	Clock delay 2

Proceed as follows:

a) Set all trimmers (R22, R29, R20, R31) to mid-position.

b) Adjust the frequency of ϕ 1 to 760 kHz (t_{cy} = 1.315 µs) using R22.

c) Adjust the clock width of the Low level of ϕ 1 to 0.4 µs using R29.

d) Adjust the clock delay $t\phi_{D2}$ to 150 ns using R31 (shift ϕ1 until the condition is fulfilled).

e) Adjust the clock width $t\phi_{PW2}$ to 0.4 µs using R20.

f) Adjust the frequency of ϕ 1 to 760 kHz (t_{cy} = 1.315 µs) using R22.

The precise values are given in the table following the above time diagram. A frequency tolerance of $\leqq \pm 5\%$ is sufficient. The mutual delays of the pulses should be within the following limits:

$t\phi_{D2}$ = 150 ns to 250 ns
$t\phi_{D1}$ = 300 ns to 550 ns

5.2.7 Input/Output Table

The individual functions of the micro computer Y7 can be checked by referring to the following table (FF stands for flip-flop).

Designation	Contact at ST23	Active state	Description H = hardware S = software	
CPU-clear	26	L	With L applied to the input, a -10-V pulse of 1.5 ms duration is applied to the reset input of the CPU and at the same time the overflow FF B20 is cleared.	H
			By CPU-Clear OVERFLOW is erased; figure entry register (T-reg.) is cleared; AF/RF-count FF and var. FF in function control Y3 are cleared (BUSY lamp goes out); internal level meter gain is set to G = 1; ROM-1 output is taken to passive. Not externally programmable.	S
EOP	4	L	Same effect as CPU-clear, but is programmable	S H
Counter data	15/S/14/R		The count (8 digits with RF, 5 digits with AF) is entered digit for digit via B10.	H
A/D converter data	10/L/9/K		The result of the 10-bit binary A/D converter is entered in 4 words of 4 bits each. The computer makes the binary/BCD conversion. The last word represents the range. Entry is via B9.	H S
Program sampling	$\overline{F}$	L	Combination of function FF, counter FF and variation FF. When it is active, BUSY lights. Sampling is made via B11.	H S

Designation	Contact at ST23	Active state	Description H = hardware S = software	
Data sampling (button sampling)	$\overline{C}$	L	The buttons are sampled via 2 data selectors, with the corresponding data selector strobes (1 and 2) and addresses.	H
			The programs are performed by the computer according to the active buttons.	S
Overflow (attenuator set)	$\overline{B}$	H	Hardware recognition whether attenuator set > 141 dB	H
Data bus	18/V/19/W	Pos. logic	The data bus comes from RAM-O B17 via 4 data lines. All data and all addresses are output via this bus. The addresses are stored in the address store B1 by application of the strobe (pin 8 of B1 at L).	H
			Switchover data/addresses is made by the micro computer.	
Talker line	11	H	Is active when the SMPU is required to output data (e.g. on pointer).	H
Overflow (display)	25	H	In the case of an inadmissible input state (from keyboard), this line turns active. This occurs when - too many decimals preceding the decimal point - more than 8 digits - AF generator value too low - RF $\geq$ 500 MHz - attenuator set > 141 dB are entered by the keyboard.	S
DAV	5	H	Data-valid strobe for data output from SMPU (see handshake data coupler, section 4.1.5).	H
Figure output strobe	8	H	Control line to data coupler	
S/N measurement	24	L $\triangleq$ mod. off	Control line for automatic S/N measurement	S
Doubler	2		Control line for 1-GHz option	
$\pm$var.-clear	27	L	Variation button is reset.	S
RF/AF counter clear	3	L	Counter button is reset.	S
Strobe clear	28	L	Function-strobe FF is reset.	S
Data selector strobe 1	$\overline{E}$	L	Is output by the computer to sample the buttons via all data selectors.	S

Designation	Contact at ST23	Active state	Description H = hardware S = software	
Address bus	17/U/T/16	Pos. logic	Address store B1 is set by micro computer; storage by strobe at pin 8.	S
dB strobe	F	L	dB display and register are activated.	S
RF display strobe	P	L	RF display is activated.	S
RF register strobe	H	L	RF register is activated.	S
AF register strobe	6	L	AF register is activated.	S
AF display strobe	1	L	AF display is activated.	S
FM/φM/V strobe	D	L	FM, φM, V display and registers are activated according to type of modulation.	
AM strobe	C	L	AM display and register are activated.	
Control line to deviation meter	I	H	Disturbance caused by change of decade of RF generator is suppressed.	

5.2.8 Relay Board Y8

See circuit diagram 240.0090 S

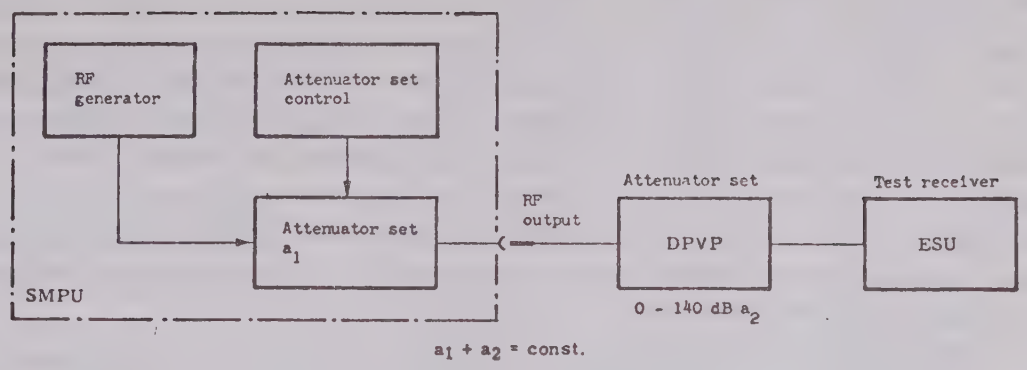
Connect an RF millivoltmeter (e.g. URV) to the RF output socket and measure the RF level at 0 dBV. Depress buttons VAR. DC and MODULATION INT. AM and apply 10% AM. Adjust the RF level with potentiometer R8 to 20 dB below normal level. Then apply 99% modulation and adjust the DC voltage with R11 so that the RF level is 1% below the normal level. Check the RF level at 50% AM. It must correspond to half the normal level.

5.2.9 Attenuator Set Control Y9

See circuit diagram 240.0184 S

No adjustments are provided in this subassembly. Its function can be checked only in conjunction with the attenuator set Y25. It is advisable to check by means of a test receiver and an external attenuator set. The sum of the two attenuations should be constant and produce a constant deflection on the test receiver.

Test setup



To cover all settings, it is sufficient to proceed up to 80 dB in BCD code (1-2-4-8). The last attenuator section and the driving circuit are checked at 100 dB. Above 141 dB up to 399 dB this subassembly must signal overflow.

The value 0 dB is to be entered into the stores B3 and B4. Apply a positive and a negative voltage of 10 to 15 V to ST25.22 (+8 V) and ST25.23 (-8 V). With the RF level switched on (H at ST25.Z) the voltage at all control lines to the attenuator set (ST25.25 to 28, ST25.$\overline{B}$ to $\overline{D}$) must correspond to the positive input voltage. With the RF level switched off (L at ST25.Z), the negative switching voltage is applied to the control lines.

Switching on and off of the RF level and the falling edge of the dB strobe at ST25.16 must produce a trigger pulse of about 1.5 ms.

Note: The circuit board must not be operated without load when a switching voltage (10 to 15 V) is applied. ($R_L \approx 65\ \Omega$ or $R_L \approx 32\ \Omega$ at the outputs 2 x 20 dB).

5.2.10 AF Generator Y10

See circuit diagram 240.0255 S

Fault location

Since the AF generator is a digitally controlled subassembly, any faults can be located rapidly. A conventional procedure is used for the analog section of the subassembly.

If, for example, a wrong frequency is output, the faulty stage can be determined quickly by means of the internal AF counter. It is only necessary to enter the frequency values 1, 2, 4 and 8 for each digit in the four frequency ranges. Should the output frequency fail to follow the entered value at any place, a defective stage must be assumed. If the same fault occurs when another parameter is entered, for example modulation depth, then the fault lies in the section microcomputer Y7/function control Y3. If the fault appears only at AF, it lies in the AF generator Y10. If the output frequency is wrong but follows nevertheless all input data in correct frequency steps, adjust in the frequency range concerned with input frequencies of 50 Hz, 500 Hz, 5 kHz and 50 kHz using potentiometers R38 to R41. If this is impossible, it may be necessary to replace defective FET switches T13 to T24 or the switch driver B8.

Should the function generator B7 fail to operate, it should be removed with great care since it becomes very hot especially when it is defective.

If the sinewave signal presents too much distortion, it is recommended that the signals at pin 4 of B7 (triangle), at MP 1 (triangle) and the signals after the switching diodes G1 3 to G1 16 be displayed on an oscilloscope to check the break points of the sinewave former. Special attention should be paid to the linearity of the triangular signal at the first two test points and to the continuity of the sinewave approximation and to the symmetry of the sinewave curve at the break points of the diode characteristics. When a component of the sinewave matrix has been changed, the matrix must be readjusted, see "adjusting the distortion".

A faulty amplitude of the sinusoidal output signal can be adjusted with potentiometer R111, see "adjusting the output level".

Adjustments

Adjusting the frequency (using the SMPU counter)

Connect socket AF 52 (Fig. 2-1) to socket AF 53 .

Press buttons XMITTER 58 and CHECK 41 .

The count appears in display 2 of the SMPU.

Select 0.05 kHz and adjust for 50 Hz with R38,
select 0.5 kHz and adjust for 500 Hz with R39,
select 5.0 kHz and adjust for 5 kHz with R40,
select 50.0 kHz and adjust for 50 kHz with R41.

The adjustment to digit 5 provides for the smallest frequency error with respect to the whole decade.

Adjusting the input voltage for the sinewave matrix

Measure with a digital voltmeter (e.g. UGD 51) and an oscilloscope at MP 1 (corresponding to the base of T25).
Enter the AF frequency of 1 kHz at the input unit.
Measure DC voltage at MP 1 and adjust to 0.2 V with R57.
Measure triangular voltage at MP 1 and adjust with R55 to V_{rms} = 2.55 V (V_{pp} = 6 V).

Adjusting the distortion

If one is sure that the fault is not in the modulation processing section, the internal distortion meter of the SMPU can be used directly for 1 kHz or 300 Hz.
Connect socket AF 52 to socket AF 53 .
Press pushbuttons for AF = 1 kHz or 300 Hz, AF level = 1 V.
Depress buttons CHECK 41 and DISTORTION 1 kHz or 300 Hz 10 .
Connect an oscilloscope to socket MOD. AF 26 .

Observing the output signal of the AF generator on the oscilloscope, adjust the sinewave signal roughly with R85 and R104, if necessary also with R55 and R57. Then make the fine adjustment by means of the distortion meter by varying these elements iteratively; instead of the built-in distortion meter an external instrument connected to socket AF 53 may be used.

Adjusting the output level

Connect an AC digital voltmeter (e.g. UGD 51) to the output of the AF generator ST26.25, C.
Press pushbuttons for AF = 1 kHz, AF level = 1 V.
Depress button MOD. GEN. INT. 38 .
Adjust the output signal at 1 kHz to V_{rms} = 1 V ±0.1% using R111.

5.2.11 Deviation Meter Y12

See circuit diagram 240.0361 S

Set the SMPU for transmitter measurement and FM measurement of useful modulation. Connect a signal generator (e.g. SMDU) to the RF output and apply a 100-MHz signal with 5 kHz deviation. Frequency deviation should be accurately adjusted by means of a deviation meter. Adjust R33 such that, with 5 kHz deviation and a suitable measurement range, a DC voltage of 2.83 V is present at MP 4.

5.2.12 AF Level Meter Y13

See circuit diagram 240.0432 S

A. Adjusting the rms meter

1. Zero adjustment of input offset
   a) Operate AF level meter without input signal.
   b) Connect digital voltmeter to MP 5.
   c) Adjust R90 for $V_{MP5} \leqq \pm 5$ mV with both the CCITT filter on and off.
2. Balance adjustment
   a) Remove bridge at MP 5.
   b) Connect digital voltmeter to MP 6.
   c) Apply +5 V and -5 V alternately and adjust R94 so that the same voltage appears in both cases at MP 6.
   d) Same as c) but with ±0.5 V, adjustment with R95.
3. Zero adjustment of output offset
   a) and b) same as 2.a) and b).
   c) Apply 0 V at MP 5-10 and adjust R96 such that the voltage at the digital voltmeter is $V_{MP6} \leqq \pm 1$ mV.
4. Gain adjustment
   a) Apply 1 V_{rms} ±0.5% to AF input (52).
   b) Connect digital voltmeter to MP6 and switch on the 1-V range (6).
   c) Adjust R105 such that the voltage at the digital voltmeter is V_{MP6} = +3 V.

B. Adjusting the AF Level Meter J1

1. Mechanical zero
   Switch the SMPU off and set the pointer of the meter to the mechanical zero by means of the screwdriver adjustment below the meter.

2. Calibration

a) Establish +3 V at MP 6 as under A.4)

b) Check the voltage for the A/D converter at ST29.2; it should be +4.89 V.

c) Adjust with R113 for f.s.d. of meter J1.

d) Connect bridge at MP 5.

C. Adjusting the single-tuned filters

1st filter, 1st stage

a) Disconnect bridge at MP 1.

b) Apply 1 V to MP 1-2 from AF generator.

c) Connect a sensitive oscilloscope to MP 2.

d) Set AF generator to 1 kHz, switch 1-kHz filter on and adjust voltage at MP 2 for minimum using R32.

e) Set AF generator to 300 Hz, switch 300-Hz filter on and adjust voltage at MP 2 for minimum using R33.

f) Adjust symmetry control R38 such that the attenuation minimum is most pronounced at both pole frequencies.

g) Repeat d), e) and f) if necessary.

h) Connect bridge at MP 1.

2nd filter, 2nd stage

a) Remove bridge at MP 2.

b) Apply 0.1 V at MP 2-4 from AF generator.

c) Connect a sensitive oscilloscope to MP 3.

d) Set AF generator to 990 Hz, switch 1-kHz filter on and adjust voltage at MP 3 for minimum using R45.

e) Set AF generator to 297 Hz, switch 300-Hz filter on and adjust voltage at MP 3 for minimum using R44.

f) Connect bridge at MP 2.

3rd filter, 3rd stage

a) Remove bridge at MP 3.

b) Apply 0.1 V to MP 3-6 from AF generator.

c) Connect a sensitive oscilloscope to MP 4.

d) Set AF generator to 1010 Hz, switch 1-kHz filter on and adjust voltage at MP 4 for minimum using R59.

e) Set AF generator to 303 Hz, switch 300-Hz filter on and adjust voltage at MP 4 for minimum using R58.

f) Connect bridge at MP 3.

5.2.13 Modulation AF Control Y14

See circuit diagram 240.0603 S

Fault location

Since this subassembly is digitally controlled, any faults, for example in the modulation depth setting can be located rapidly. A conventional procedure is used for the analog section of the subassembly.

Four basic groups of fault may appear in digitally programmable analog circuits:

1) Data and commands from the data bus (ST30.17/4/18/V), address bus (ST30.16/T), strobe lines (ST30.J/8) or function control lines (ST30.$\overline{F}$/X/W/19) do not arrive in the correct form on the circuit board.

2) The available data and commands are processed incorrectly in the digital section.

3) The analog section shows the usual faults.

4) The operating voltages are incorrect; this is obvious when other subassemblies show the same faults.

Fault group 1: Fault location in the micro computer Y7 and function control Y3.

Fault group 2: If the data and command entry at the board inputs is correct, the faulty digit and corresponding decade can be determined by varying modulation depth, deviation or phase modulation on the front panel (knob 25 in Fig. 2-1). It is sufficient to check the values 1, 2, 4 and 8 in the three decades. The fault location procedure is preferably commenced at the data store outputs of B20, B21 and B22.

If, for example, the 8-kHz bit is to be switched on with FM, B21/17 must be at +5 V, B30/11 also at +5 V, B30/10 at 0 V and B5/1 at 0 V. If a different voltage is found in any of these stages, the corresponding circuit should be replaced or associated components be checked. Proceed similarly to check the function control.

The discrete FET switches of type E 111 A, e.g. T10, must be cut off if -20 V is applied to their gates; they conduct when the output transistor of the switch driver D 125 EK, e.g. B33/14, is currentless. The gate of FET T10 is controlled via resistor R96 by the AF signal applied, so that permanently V_{GS} = 0 V, meaning that the FET conducts.

Fault group 3: If the output parameters are wrong but vary in correct relative steps, the fault is in the analog section. Possible causes:

- The input voltage of the modulation AF control is not correctly calibrated.

- One or more operational amplifiers or their wiring is defective.

It is best to follow the AF signal path by means of an oscilloscope and/or digital voltmeter from one operational-amplifier output to the other until the defective part is found.

Adjustment

To adjust the modulation depth in operation with the electronic attenuation standard, proceed as follows:

- Depress buttons RECEIVER 57 , MODULATION 42 , MODULATION INT. AM 37 , VAR. DC 34 .
- Enter RF level in % (99%) with % button 17 .
- Enter modulation depth in % (90.0%) with kHz button 17 .

Connect modulation-depth meter to RF output 49 .

Adjust the modulation depth (90%) to the nominal value using potentiometer R5.

The modulation depth must remain constant up to an RF level of 20%. If it varies, the DC voltages produced on the relay board must be readjusted (see section 5.2.8).

5.2.14 RF Overload Protection and ALC Y15

See circuit diagram 239.3619 S

RF overload protection

Connect an RF signal generator to the RF output BU10 of the SMPU. Set the signal generator to 100 MHz and 50 mW and check the level with an RF power meter, e.g. Microwave Power Meter NRS.

Set SMPU for receiver measurement and set the RF level to -140 dB.

Increase signal-generator level. Adjust R35 on control amplifier board 239.3931 so that the RF overload protection responds at 300 mW.

ALC

The adjustment should be made when the ALC circuit is incorporated in the SMPU.

1. Adjustment to nominal value
   a) Set SMPU for receiver measurement, attenuation 0 dB and frequency 100 MHz. Switch the modulation off with button MODULATION 42 .
   b) Vary R55 until the power meter (e.g. NRS) connected to the RF output BU10 indicates 5 mW.
2. Adjustment of inverse modulation
   a) Same as 1.a.
   b) Remove connecting cable between the ALC sockets (rear) of the Control Unit and the Indicator.
   c) Apply about 2.8 V DC from a power supply to the ALC socket of the Indicator, such that an RF power of 5 mW is measured with the power meter (e.g. NRS) at BU10.
   d) Set the modulation frequency of 90 Hz and modulation depth 90% on the SMPU.
   e) Connect an oscilloscope to the ALC check point and adjust R57 for minimum ripple of the displayed ALC voltage.
3. Adjustment of output coupling compensation
   a) Same as 1.a (restore ALC connection).
   b) Set the modulation frequency of 5 kHz and modulation depth of 90% on the SMPU.
   c) Connect an oscilloscope to the ALC check point and adjust R45 such that a voltage curve with a horizontal top is obtained.
4. Readjustment
   a) Repeat adjustment 1.
   b) Repeat adjustments 2a, 2d and 2e.

5.2.15 Modulator Y16

See circuit diagram 239.5805 S

5.2.15.1 Fault Location

Possible fault	Remedy
Oscillator falls out of step	
Oscillator divider or reference divider defective or input amplifier of oscillator divider or reference divider supplies a level too low for the TTL circuits.	Replace TTL divider or input amplifier.
Monostable B20 in phase discriminator does not trigger correctly; consequently no sawtooth, oscillator free-running.	Replace B20
Switching transistors T13 or T15 in phase discriminator defective (possibly due to overvoltage).	Use earthed soldering iron when inserting the new transistors. After soldering, remove wire loop from transistor contacts.
Failure of a supply voltage in the sub-assemblies of the synchronization loop.	Check supply voltages.
No reference voltage appears at ST3.	Repair frequency generating circuit of SMPU Indicator.
Reactance diodes G1 10 and G1 11 in oscillator defective or operating point of diodes has drifted.	Replace reactance diodes or adjust operating point with R14. Then adjust modulation distortion with C22.
Capture range of synchronization circuit too small due to defect in phase discriminator at sawtooth former T11, T12 or pulse formers T16 and T17.	Replace defective components.
Preset deviation is not attained by the modulator	
AF/FM voltage at ST1 differs from V_{rms} = 4 V/100 kHz deviation.	Fault location in modulation AF control Y14.
Operating point of oscillator drift (e.g. due to diode aging)	Adjust with R2 of control board and with R14 and C22 of oscillator. Connect deviation meter to ST4 or to RF socket on front panel.
Reactance diodes in oscillator defective.	Replace reactance diodes.
Oscillator does not operate at 30 MHz $\pm$10 kHz in unsynchronized mode	
Control voltage Vφ is not 0.	Readjust with R86.
Oscillator is out of tune (e.g. due to vibration)	Adjust oscillator frequency to 30 MHz with L10.
Operating point of reactance diodes has drifted.	Adjust with R14; then readjust modulation distortion with C22.
AM modulator does not reach preset values for AM modulation	
AF/AM voltage at ST2 is not at the correct level of V_{rms} = 35.7 mV/% mod.	Adjust with R159 in modulation AF control Y14; if not possible, repair Y14.

Possible fault	Remedy
AF/AM voltage does not reach the base of T21.	Check AM filters I and II of modulation AF control Y14.
RF voltage does not reach the collector of T20.	Check T20 and oscillator.
<u>AM distortion too high</u>	
T21 or T22 defective.	Replace.
Operating point of T21, T22 drifted.	Adjust with R100 (modulation frequency 1 kHz, demodulator connected to RF output on front panel and distortion meter to AF output of demodulator)
B25 defective, causing unsymmetrical amplitude modulation.	Replace
T24 limits, causing AM distortion.	Check operating point of T24.
<u>No RF level at RF output ST4, with modulation</u>	
Oscillator transistor T1 fails.	Replace T1 and adjust operating point.
Short-circuit in RF path of AM modulator.	Check signals at T20, B25/3, B25/1, base T24, collector T24.
Modulator switch does not conduct:	
- Switching diode defective - Switching voltage not present - G1 26 shorted	Replace defective component.
- Function control line has wrong levels	Check function control Y3 and B30, B31 in switch control.
<u>No RF level at RF output ST4, without modulation</u>	
Reference frequency does not reach ST3.	Repair of frequency generation in Indicator
Reference switch defective: - Switching diodes defective - Switching voltage not present - G1 31 or G1 33 shorted.	Replace defective component.
<u>RF level at ST4 in unmodulated mode differs from that in FM mode</u> (causing level jumps at RF output of SMPU upon switchover)	
R130 in modulator switch misadjusted	Adjust to same RF level as obtained with FM. If necessary, correct with R20 in oscillator.
Gain of AM modulator has slightly changed.	Readjust with R130 in modulator switch.

5.2.15.2 Adjustment

Centre frequency of free-running oscillator:

Press buttons DUPLEX 56 and FM DC 32 .

Set RF level to 0 dBV and RF frequency to 30 MHz.

Press buttons MODULATION (ON) 42 , MODULATION INT. FM 37 and CHECK 41 .

The oscillator frequency f_o is displayed in 1 .

Measure the control voltage V at contact 34 of phase discriminator and adjust to 0 V with R86.

Adjust oscillator frequency f_o to 30 MHz by turning the ferrite core of L10.

Deviation characteristic

Connect an unmodulated signal generator to the RF socket 49 or 48 . Depress buttons XMITTER 58 , MODULATION INT. FM 37 and MOD. MEAS. FM 36 .

Adjust an AF frequency of 1 kHz and FM deviation of 20 kHz. Meter 14 indicates the deviation; adjust with R2 on the control board.

FM distortion

Connect socket 26 to 52 .

Make the adjustments as for the deviation characteristic and depress the button DISTORTION 1 kHz 10 .

FM distortion is displayed in 2 .

Adjust alternately with R14 and R22 in the oscillator or at the sine matrix of the AF generator Y10.

AM modulation depth

Connect modulation meter to RF socket 49 .

Depress buttons RECEIVER 57 and MODULATION INT. AM 37 .

Adjust RF frequency of 10 MHz, RF level of -40 dBV, modulation frequency of 1 kHz and modulation depth of 90%.

The modulation meter indicates the modulation depth of the AM modulator. Adjust R159 in the AM modulator so that the modulation depth measured at the RF output is equal to that adjusted on the SMPU.

AM distortion

Connect AF output of demodulator to socket 52 .

Make the adjustments as for AM modulation depth and depress the button DISTORTION 1 kHz 10 .

AM distortion is displayed in 2 .

Adjust with R100 in the AM modulator.

RF output voltage at socket 71

Connect an RF millivoltmeter, e.g. URV, to socket 71 .

Without modulation: RF level $V_{rms} \approx 90$ mV; adjust with R130 in the modulator switch.

5.2.16 Power Meter Y21

See circuit diagram 239.8510 S

The whole adjustment should be carried out while the power meter is inserted in the SMPU.

1. Mechanical zero setting
   Switch the SMPU off and adjust the pointer of the meter to the mechanical zero by means of the screw provided below the meter.

2. Electrical offset adjustment
   a) Switch the SMPU on, do not apply an RF signal.
   b) Set SMPU for receiver measurement and adjust for zero of meter with R31 (V_{MP2} = 0 V).
   c) Set SMPU for transmitter measurement; adjust for 0.5 on meter by means of R7, i.e. V_{MP2} = 0.49 V.

3. Electrical calibration of power meter
   a) Switch the SMPU on and set for transmitter measurement.
   b) Connect a power signal generator (e.g. SMLU) with 250 mW at 100 MHz, unmodulated.
   c) Adjust the voltage at MP2 to 4.9 V using R4.

4. Electrical calibration of meter
   a) Switch the SMPU on and set for transmitter measurement.
   b) Connect a power signal generator with 250 mW at 100 MHz, unmodulated.
   c) Adjust for f.s.d. of the meter using R32.

5.2.17 Display Control Y22, Display Y23

See circuit diagram 41105/2-3 S

Fault location

The display control Y22 and display Y23 are of digital design. They can be operated and checked separately via the 24-pole plug ST18; for contact occupation see table 5-3. Static checking of the logic combinations is possible.

The data transfer to the hexadecimal displays is serial via the data and address busses in positive logic. The data word appears with the L state of the strobe (RF, AF indication, AM, FM or dB strobe) at the display corresponding to the address word. The LSB has the address 0. For fault location it is best to work with binary code (1-2-4-8).

The shifting of the decimal point of the AF display is operative when the control line AF count ST3.4 (ST19.14) is at L state. The range is entered with address 3 by the AF indication strobe ST2.8. The decimal point shifts from left to right with increasing data word:

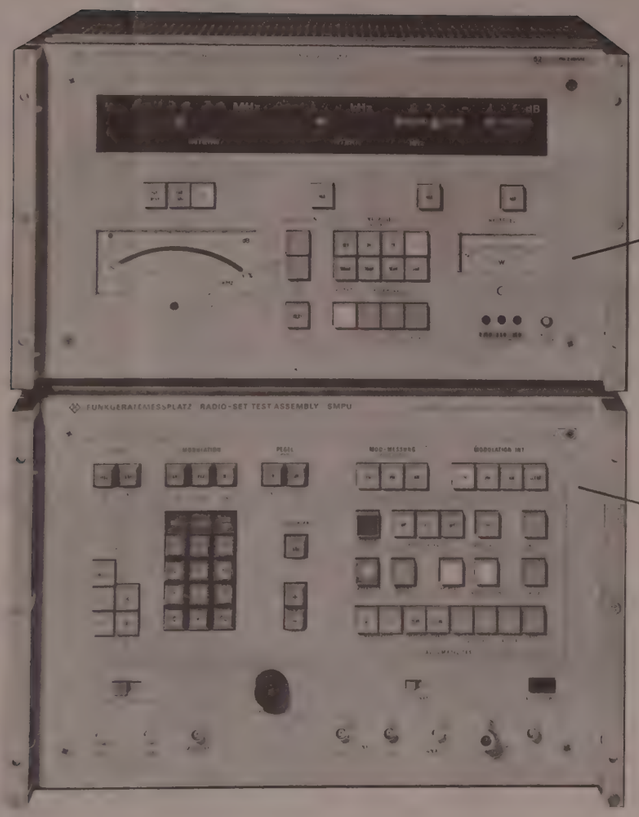
Data word	Decimal point after
0	1st place
1	2nd place
2	3rd place
3	4th place

The remaining control lines are in positive logic.

5.2.18 Prescaler and Mixer Y20

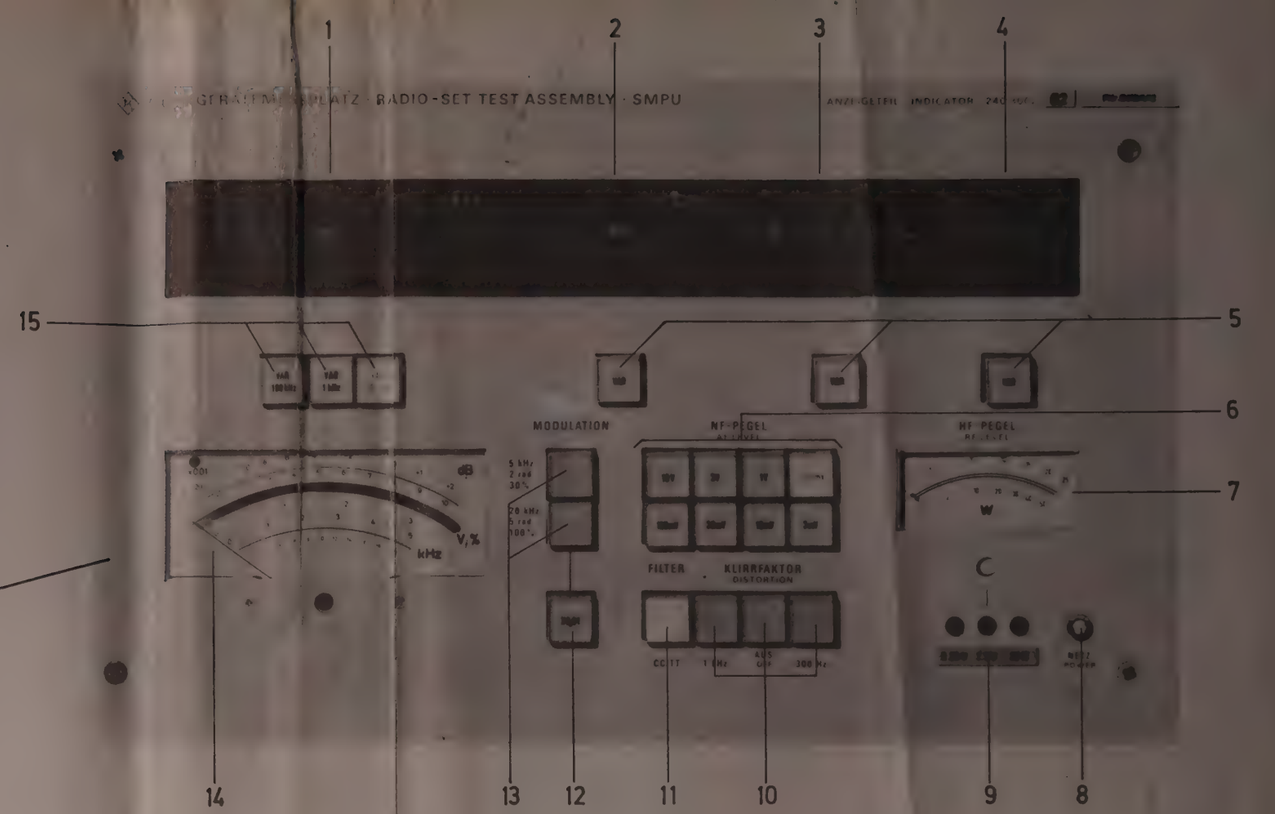
Adjustment

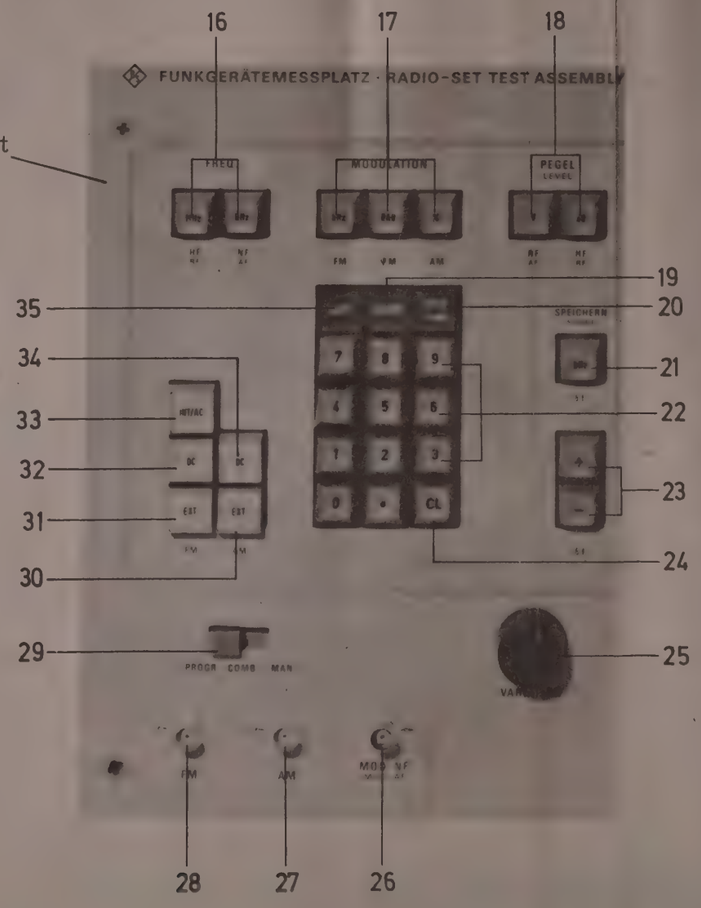
The prescaler 239.7672 includes an adjustment point. Adjust potentiometer R83 so that the gate time switches from 0.1 s to 0.8 s in the frequency range 65 to 70 MHz.



Anzeigeteil
Indicator

Steuerteil
Control unit





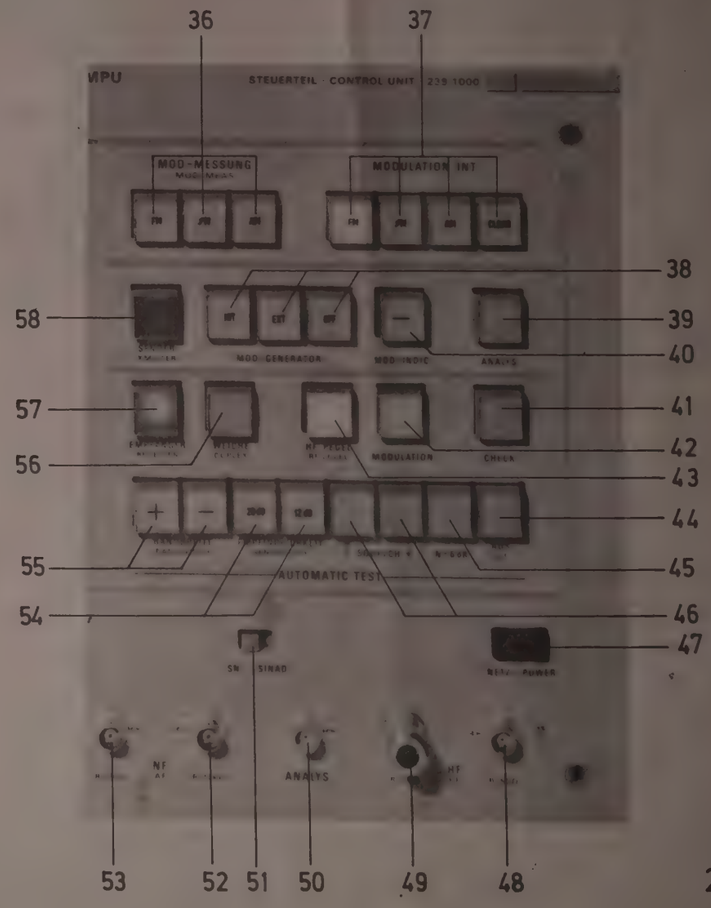


Bild 2-1 Bedienbild Frontseite

Fig. 2-1 Front panel

R 30551 - 51

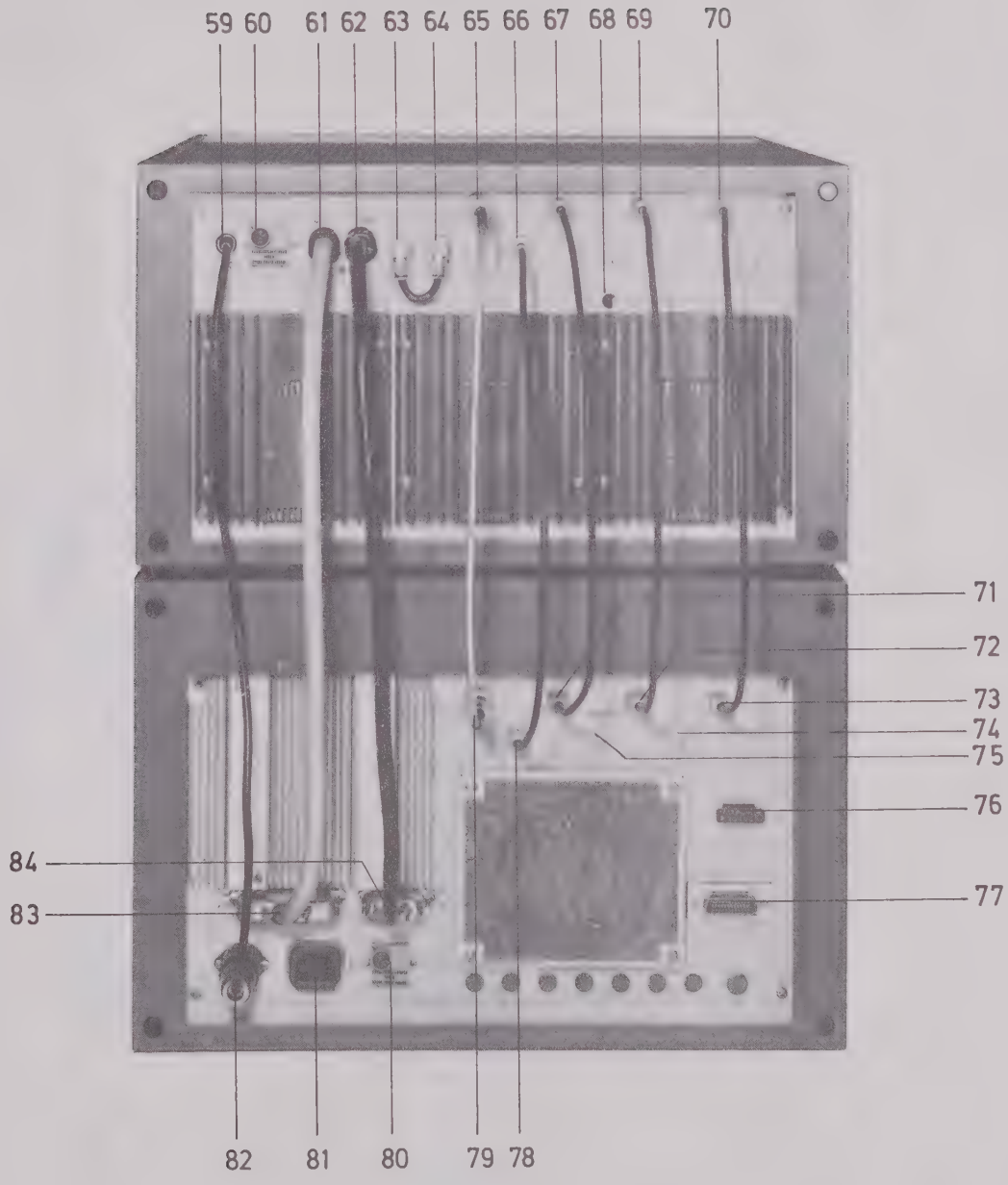
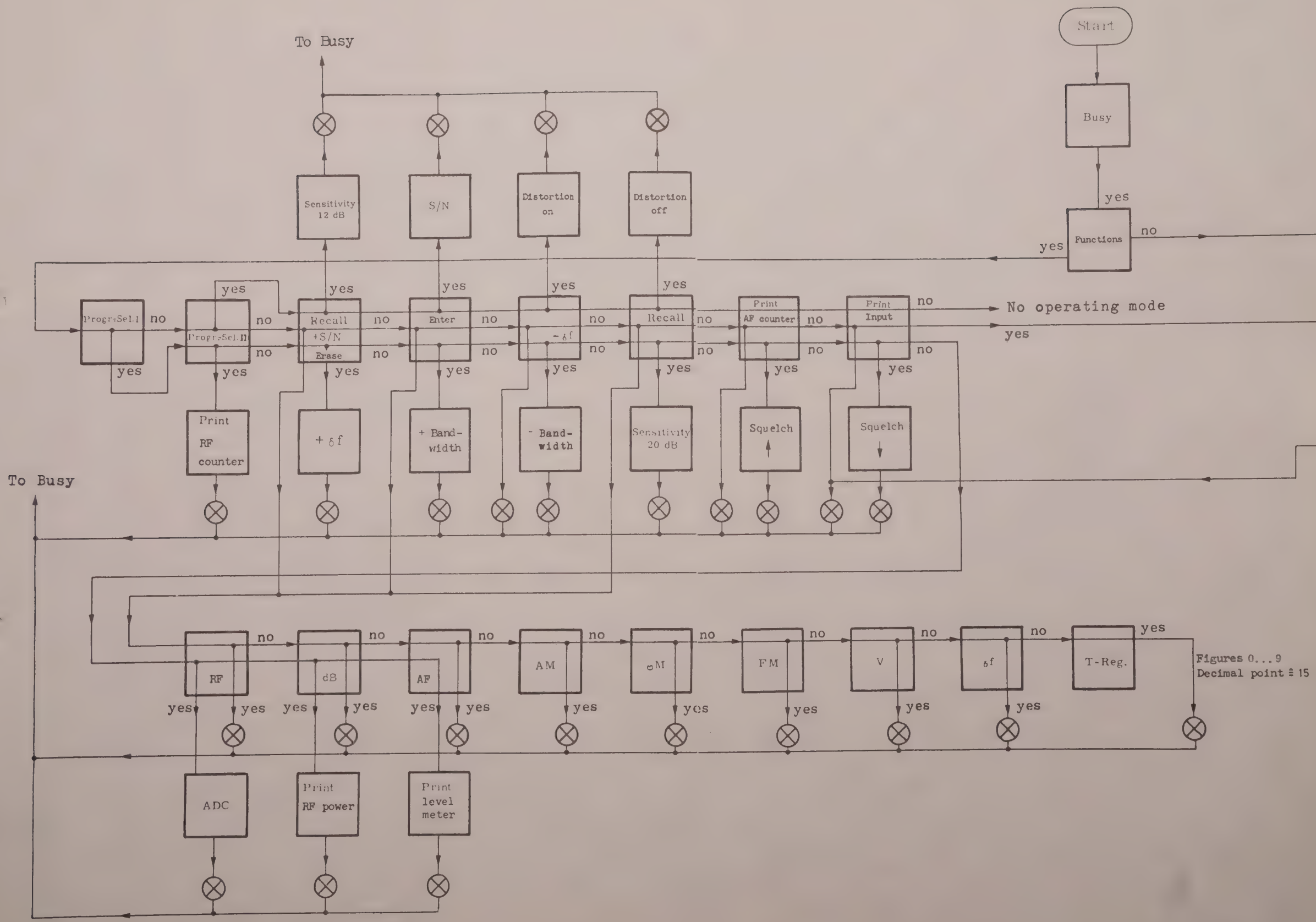
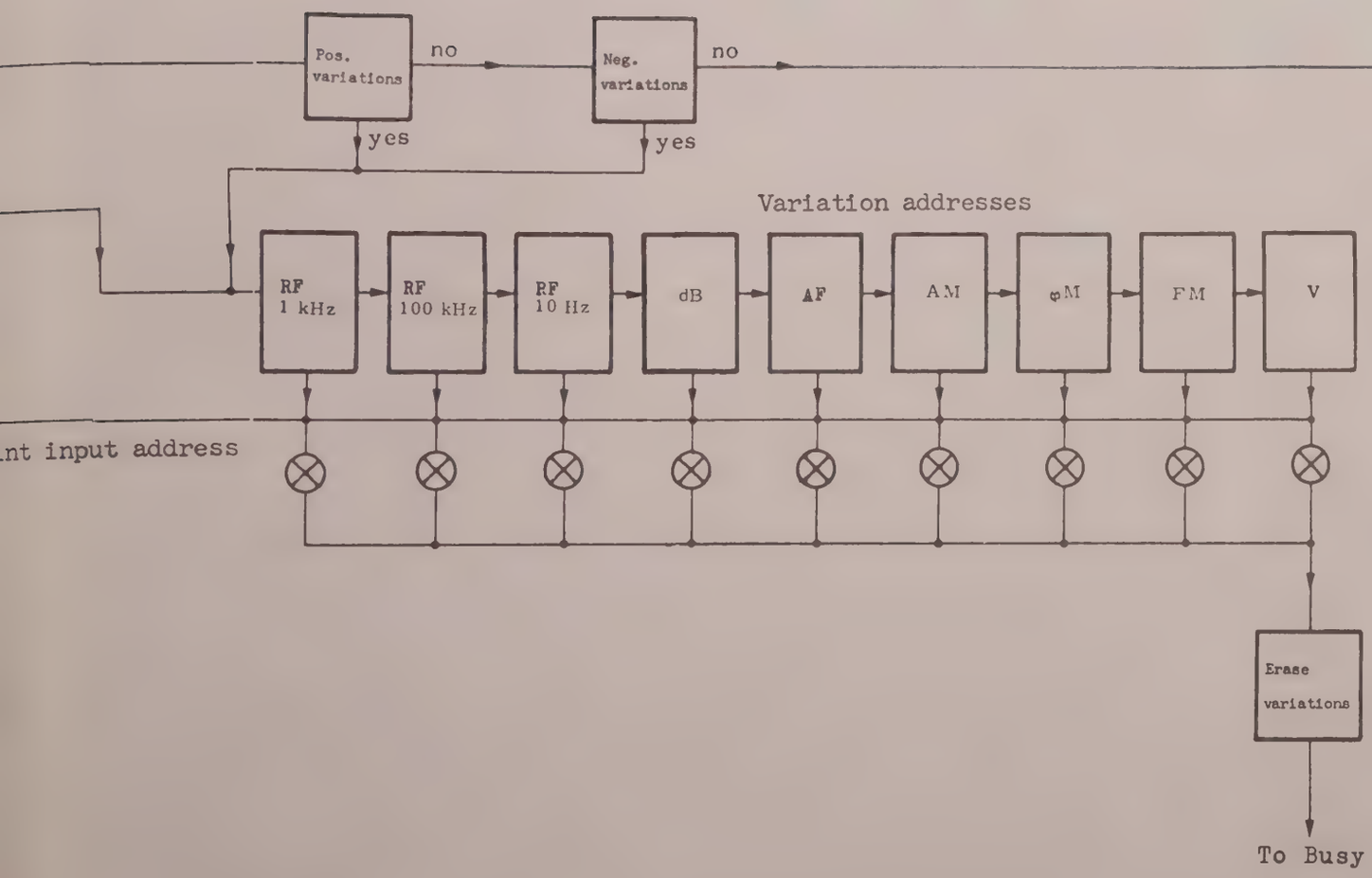
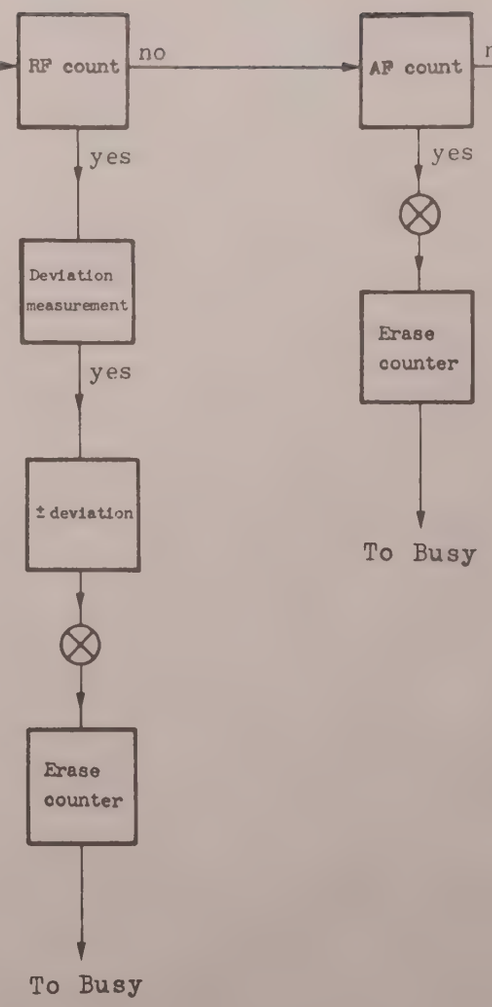


Bild 2-2 Bedienbild Rückseite

Fig. 2-2 Rear panel


Start
Busy
yes
Functions
no
yes
To Busy
Sensitivity 12 dB
S/N
Distortion on
Distortion off
Progr.Sel.I
Progr.Sel.II
Recall +S/N Erase
Enter
- δf
Recall
Print AF counter
Print Input
no
yes
No operating mode
Print RF counter
+ δf
+ Band-width
- Band-width
Sensitivity 20 dB
Squelch
Squelch
To Busy
RF
dB
AF
AM
φM
FM
V
δf
T-Reg.
Figures 0...9
Decimal point ≙ 15
ADC
Print RF power
Print level meter





⊗ means program execution

Flow chart for table of individual function (for micro computer Y7)

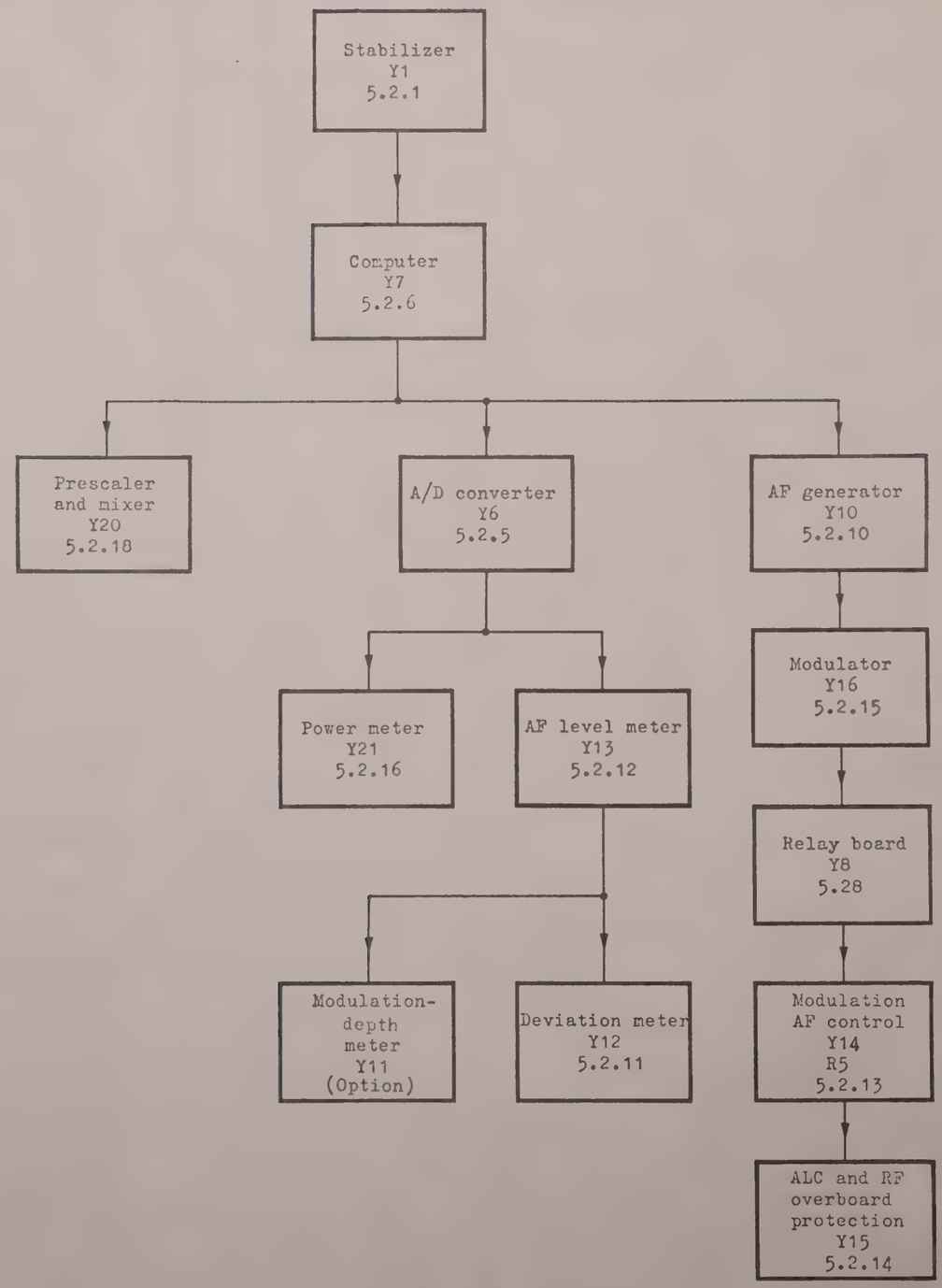


Table for adjustement of SMPU Control Unit

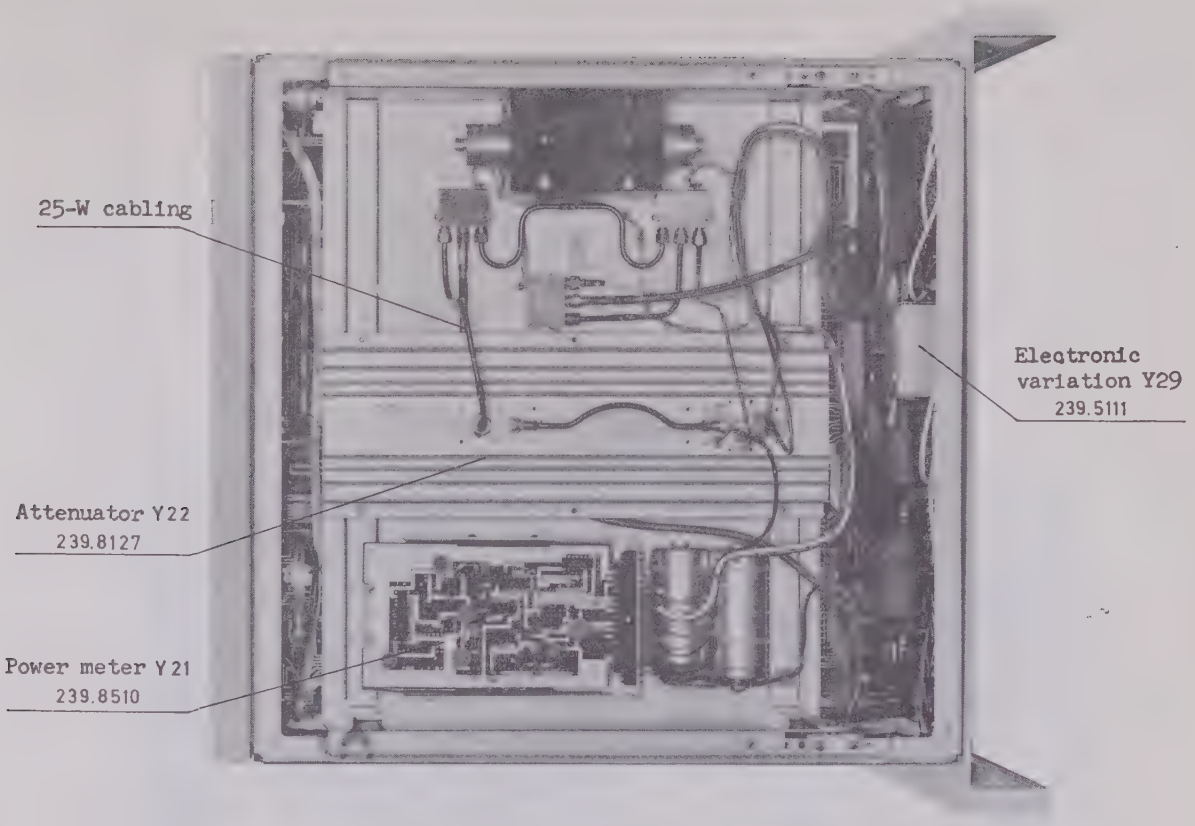


Fig. 5-2 Inside view from below, with 25-W cabling

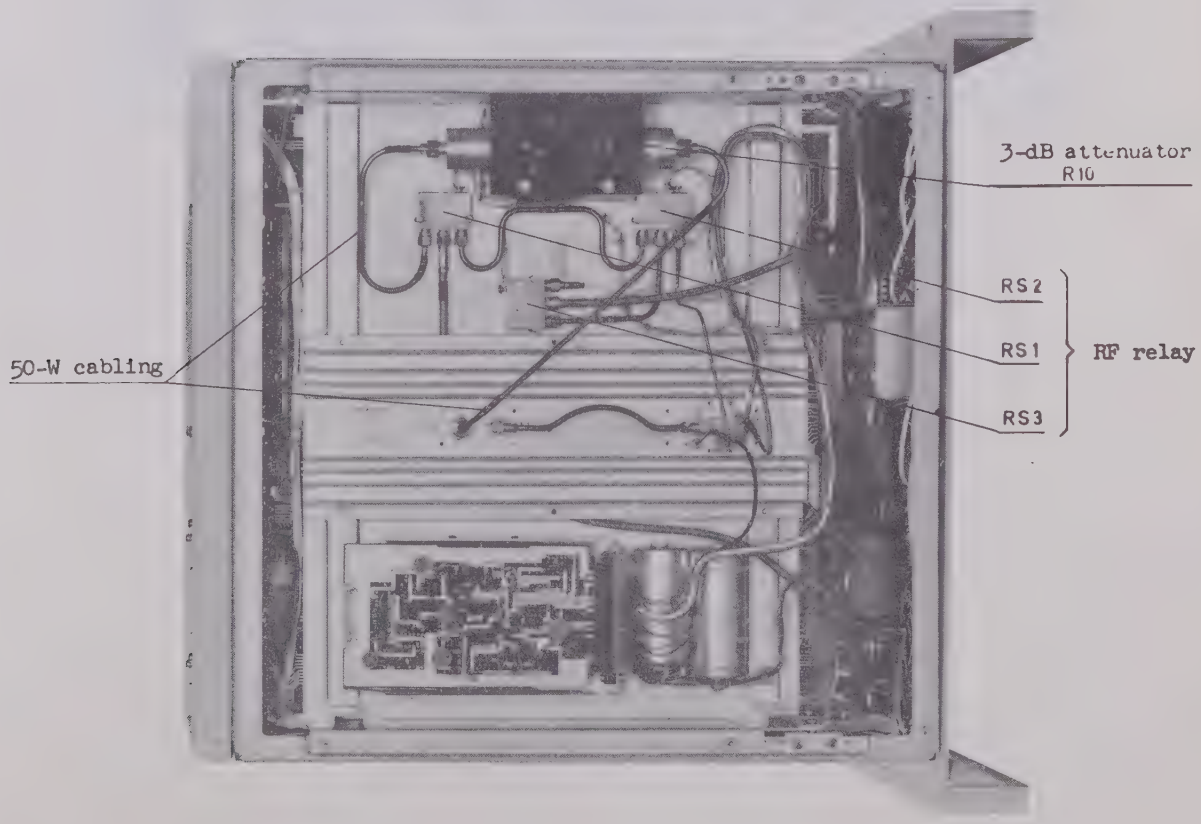


Fig. 5-3 Inside view from below, with 50-W cabling

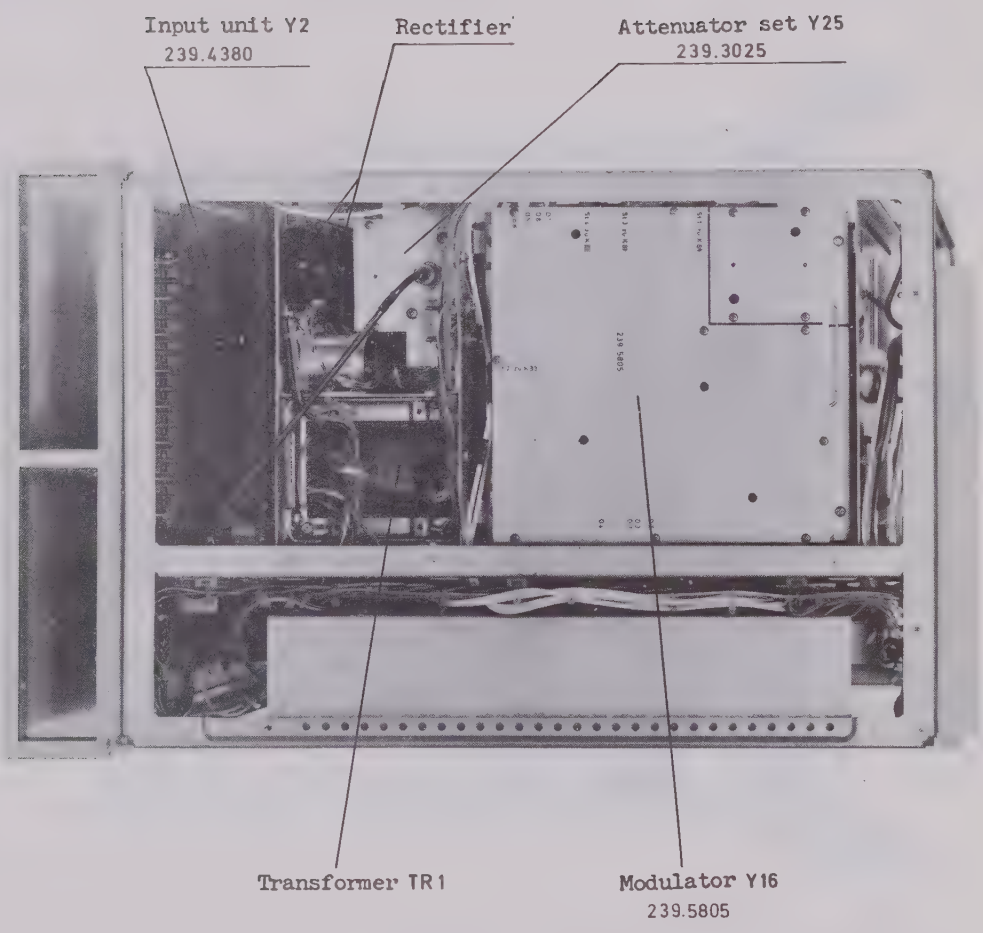


Fig. 5-4 Inside view from right

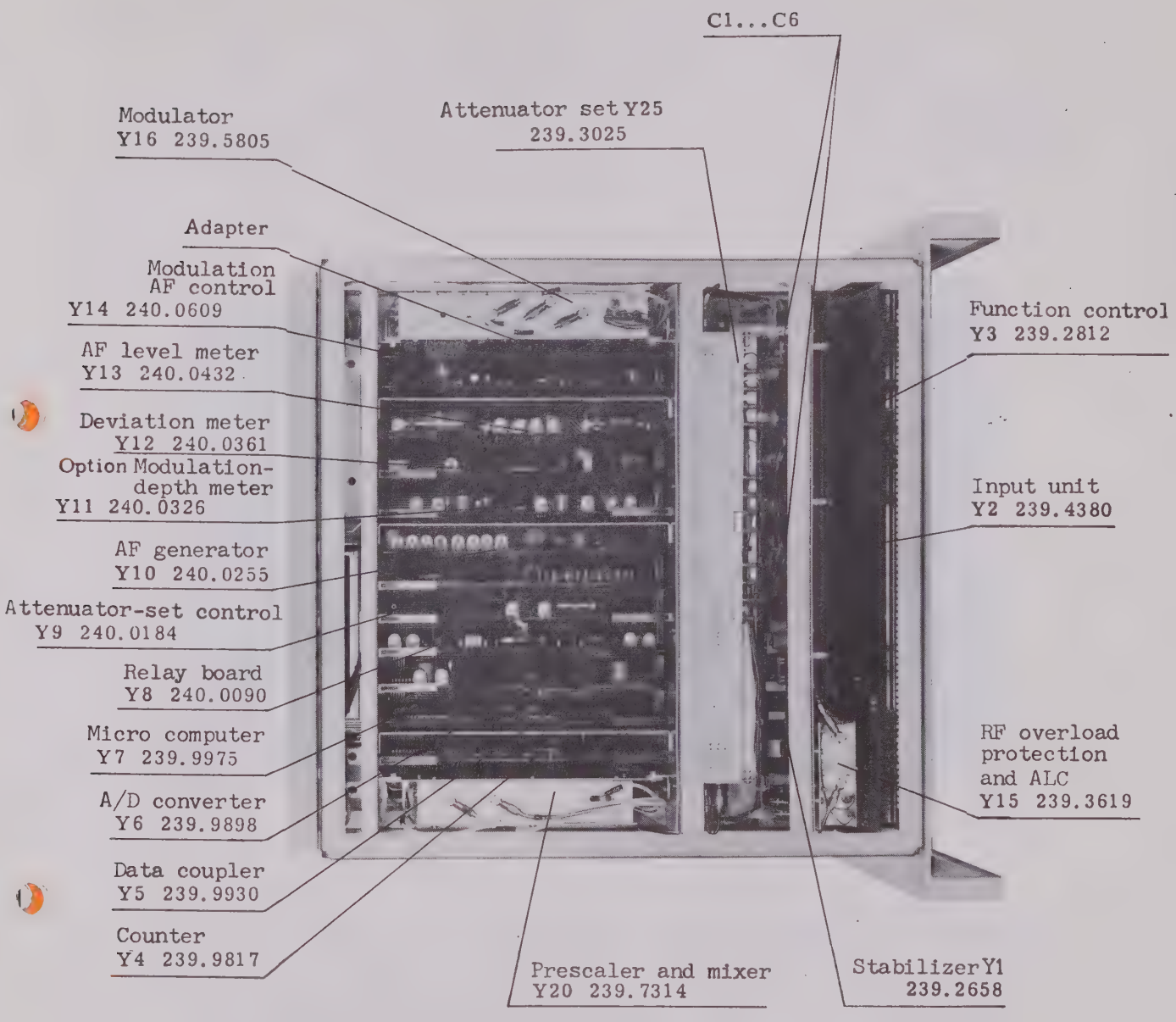
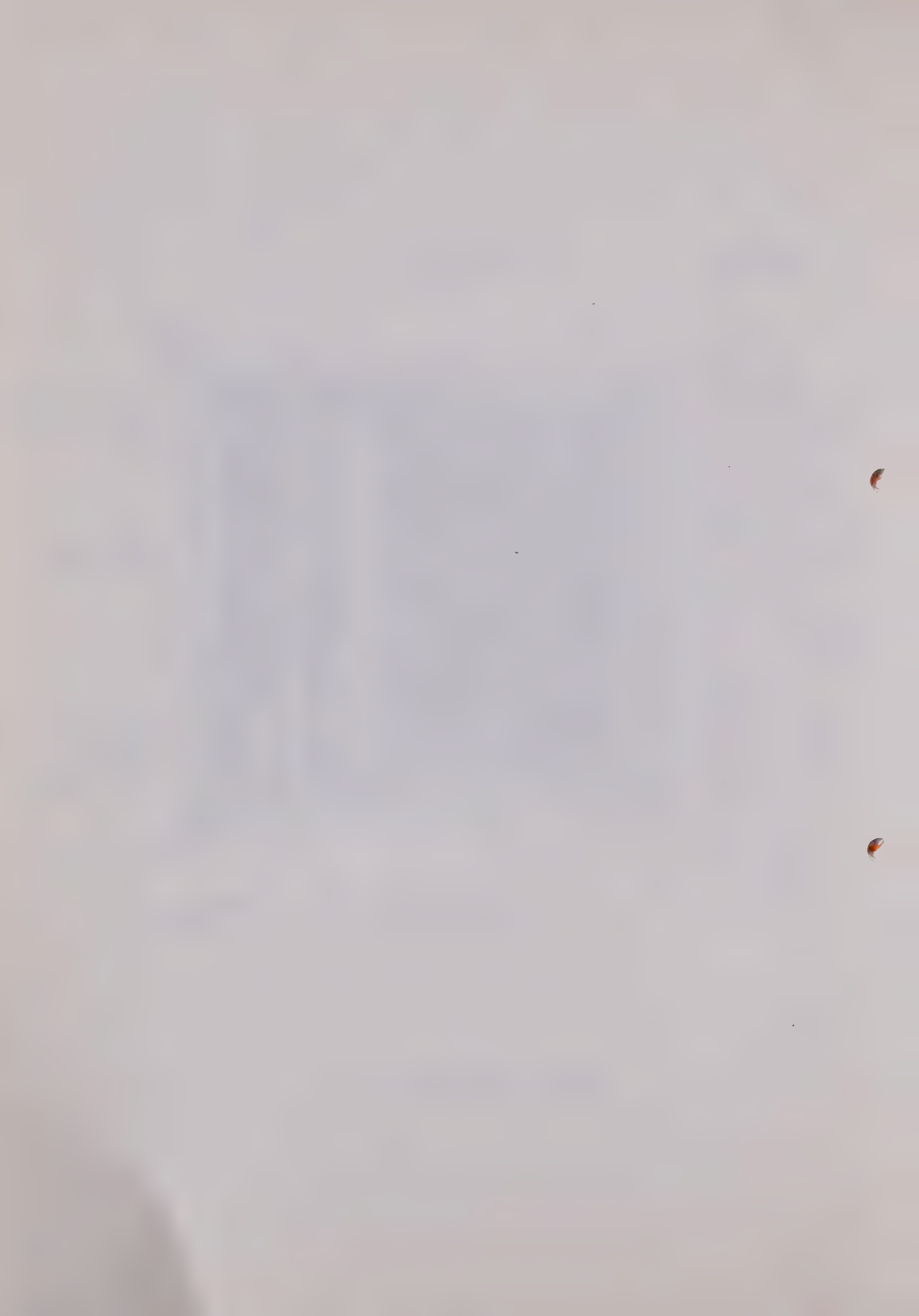


Fig. 5-5 Inside view from top



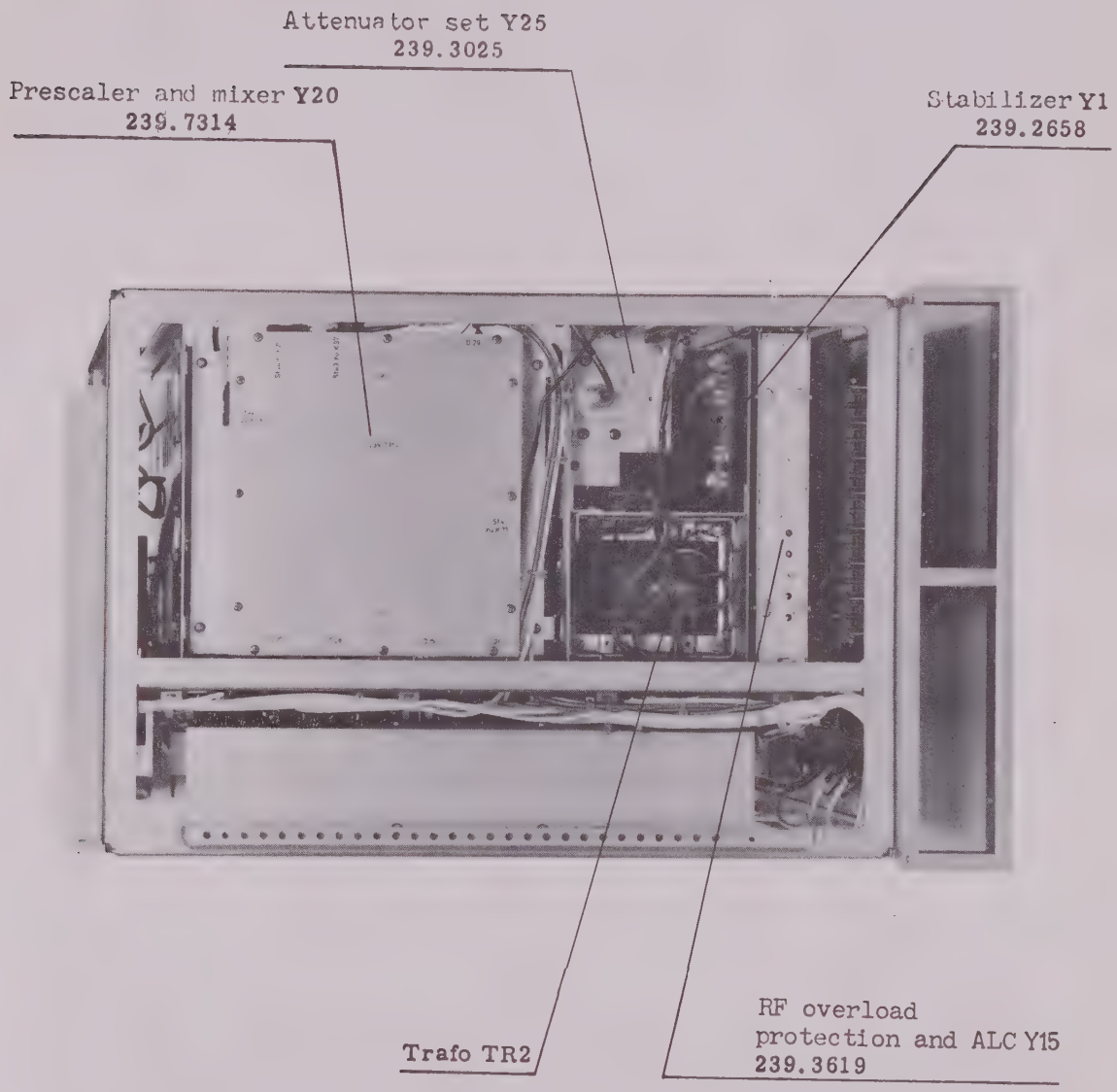


Fig. 5-6 Inside view from left

Table 4-1 Storage contents of ROM B7 in function control Y3

Button (Fig. 2-1)	ASCII character	Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
16 RF	@ ←	RF entry	74 67 87	A-RF Entry Strobe		
16 AF	I ↑	AF entry	67 72 87	Entry A-AF Strobe		
17 FM	A ↑	FM entry	67 77 87 02	Entry A-FM Strobe Int. mod. gen. OFF	2 kHz	
17 φM	E ↑	φM entry	67 76 87 02	Entry A-φM Strobe Int. mod. gen. OFF	2 rad	
17 AM	I ←	AM entry	78 67 87	A-AM Entry Strobe	2 %	
18 AF	F ←	AF-level entry	75 67 87	A - V Entry Strobe	2 V	
18 RF	B ←	RF-level entry	73 67 87	A - dB Entry Strobe		
21	D ←	δf-entry	79 67 87	A - δf Entry Strobe		
22	0,1,2,3,4,5, 6,7,8,9,.	Figure entry (0 to 9 and point)	67 87	Entry Strobe		
33	N [	OFF	35	AM-EXT, VAR-DC FM-EXT, FM-DC OFF		30,31,32, 34
32	K [	FM - DC	39	FM - DC	32	
15 +	O [	+ δf	64	Progr.-Selector 1		
15 -	B Z	- δf	68 87	- δf Strobe		
31	M [	FM - EXT	37	FM - EXT	31	
34	J [	VAR. DC	38	VAR. DC	34	
30	L [	AM - EXT	36	AM-EXT	30	

Button (Fig. 2-1)	ASCII character	Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
36 FM	H Y	FM-MOD.-MEAS.	23 18 32	Dev. meas. ON FM ON AM meas. OFF	36 FM	36 φM 36 AM
36 φM	K Y	φM-MOD.-MEAS.	23 19 32	Dev. meas. ON φM ON AM meas. OFF	36 φM	36 FM 36 AM
36 AM	N Y	AM-MOD.-MEAS.	22 24	Dev. meas. OFF AM meas. ON	36 AM	36 FM, 36 AM
37 FM	G \	FM MOD. INT.	00 04 77 13 02 10 44 12 69 87	FM-Mod. ON φM-Mod. OFF A-FM Modulation OFF Int.mod.-gen.OFF Ext.mod.-gen.OFF AF count OFF Modulation ON/OFF Recall Strobe	36 FM 3 kHz 2 MOD.-GEN.	37 φM 38 INT. 38 EXT.
37 φM	B \	φM MOD. INT.	01 05 76 13 02 10 44 12 69 87	FM-Mod. OFF φM-Mod. ON A-φM Modulation OFF Int.Mod.-Gen.OFF Ext.Mod.-Gen.OFF AF count OFF Modulation ON/OFF Recall Strobe	37 φM 3 rad 2 MOD.-GEN. 42	37 FM 38 INT. 38 EXT.
37 AM	L \	AM MOD. INT.	07 78 13 02 10 44 12 69 87	AM-Mod. ON A-AM Modulation OFF Int.Mod.-Gen.OFF Ext.Mod.-Gen.OFF AF count OFF Modulation ON/OFF Recall Strobe	37 AM 3 % 2 MOD.-GEN. 42	38 INT. 38 EXT.
37 CLEAR	C X	CLEAR MOD. INT.	06 04 01	AM-Mod. OFF φM-Mod. OFF FM-Mod. OFF		37 AM 37 φM 37 FM
58	J W	XMTR TEST	84 03 21 72 75 61 60 54	Analyser OFF Int.Mod.-Gen. ON Mod. meas. A-AF A-V Progr. lamps Clear Test lamps clear Xmtr test lamp	38 INT. 13 3 V 58	39 6 45, 46, 54, 55 56, 57

Button (Fig. 2-1)	ASCII character		Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
				61	Zero setting		
				15	RF level OFF		43
				45	RF count ON	1 EXT.	
				87	Strobe		
				13	Modulation OFF		37 FM,φM, AM; 42
				10	Ext.Mod.-Gen.OFF		38 EXT.
				44	AF count OFF	2 MOD.-GEN.	
				51	+ Mod.		40
				30	Useful mod.		12
				41	Xmtr ON	9	
38 INT	L	↑	INT. MOD. GEN.	44	AF count OFF	2 MOD.-GEN.	
				61	Zero setting		
				72	A-AF		
				75	A-V	3 V	
				87	Strobe		
				03	Int.Mod.-Gen.ON	38 INT.	
				10	Ext.Mod.-Gen.OFF		38 EXT.
				13	Modulation OFF		37 FM, φM, AM; 42
				30	Useful mod. ON, Spurious mod. OFF		12
38 EXT	E	↓	EXT. MOD. GEN.	02	Int.Mod.-Gen.OFF		38 INT.
				11	EXt.Mod.-Gen.ON	38 EXT.	
				43	AF count ON	2 RESULT	
				30	Useful mod.		
38 OFF	F	X	MOD. GEN. OFF	10	Ext.Mod.-Gen.OFF		38 EXT.
				43	AF count ON	2 RESULT	
				02	Int.Mod.-Gen.OFF		
				30	Useful mod. ON Spurious mod. OFF		
				31	Useful/spurious mod. ON/OFF	12	
	@	X	- MOD. IND. OFF	51	+ Mod. ON, - Mod. OFF		40
	A	X	- MOD. IND. ON	51	+ Mod. ON, - Mod. OFF		
40				50	+/- Mod. ON/OFF	40	
	D	W	ANALYSER OFF	84	Analyser OFF		39
	E	W	ANALYSER ON	84	Analyser OFF		
39				83	Analyser ON/OFF	39	
				74	A-RF		
				20	AF meas.	6	13
				61	Zero setting		
				15	RF level OFF		43
				45	RF count ON	1 EXT.	
				87	Strobe		
				13	Modulation OFF		42
				10	Ext.Mod.-Gen.OFF		38 EXT.
				44	AF count OFF	1 MOD.-GEN.	

Button (Fig. 2-1)	ASCII character	Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
			51	+ Mod. ON		40
			30	Useful mod. ON		12
			41	Xmtr ON	9	
57	@ U	RECEIVER TEST	60	Test lamps clear		56, 58
			55	Rec. test lamp	57	
			42	Xmtr OFF		9
			58	Reserve		
			61	Progr. lamps clear		45, 46
			72	A-AF		54, 55
			73	A-dB		
			47	A-Mod.	3 rad,kHz or %	3 V
			74	A-RF		
			87	Strobe		
			66	Zero setting		
			02	Int.Mod.-Gen.OFF		38 INT.
			20	AF meas.	6	13
			15	RF level OFF		
			14	RF level ON/OFF	43	
			51	+ Mod.		40
			30	Useful mod.		12
			10	Ext.Mod.-Gen.OFF		38 EXT.
			44	AF count OFF	2 MOD.-GEN.	
			46	RF count OFF	1 INT.	
			58	Reserve		
			84	Analyser OFF		39
56	L V	DUPLEXER TEST	58	Reserve		
			56	Duplexer test lamp	56	
			41	Xmtr ON	9	
			46	see receiver test		
			61			
			72			
			73			
			47			
			74			
			87			
			66			
			02			
			20			
			15			
			14			
			51			
			30			
			10			
			44			
			13			
			12			
			84			
43	J]	RF LEVEL OFF	15	RF level OFF		43
	K]	RF LEVEL ON	15	RF level OFF		
			14	RF level ON/OFF	43	
			69	Recall		
			73	A-dB		
			74	A-RF		
			87	Strobe		

Button (Fig. 2-1)	ASCII character		Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
	@	[	MODULATION OFF	13	Modulation OFF		42
	A	[	MODULATION ON	13	Modulation OFF		
42				47	A-Mod.	3 kHz, rad or %	3 V
				72	A-AF		
				02	Int.Mod.-Gen.OFF		38 INT.
				10	Ext.Mod.-Gen.OFF		38 EXT.
				44	AF count OFF	2 MOD.-GEN.	
				12	Modulation ON/OFF	42	
				69	Recall		
				87	Strobe		
41	M	R	CHECK	69	Recall		
				75	A-V	2 V	
				57	Check lamp	41	
				45	RF count ON	1 EXT.	
				43	AF count ON	2 RESULT	
				03	Int.Mod.-Gen.ON	38 INT.	
				72	A-AF		
				30	Useful mod.		12
				20	AF meas.	6	13
				10	Ext.Mod.-Gen.OFF		38 EXT.
				87	Strobe		
55 +	F	T	+ BANDWIDTH	61	Progr. lamp Clear		45,46,54, 55
				91	+ bandwidth lamp	55 +	
				67	Entry		
				13	Modulation OFF		42
				64	Progr. selector 1		
				72	A-AF		
				47	A-Mod.	3 kHz, rad or %	3 V
				15	RF level OFF		
				02	AF count OFF	2 RESULT	
				14	RF level ON/OFF	43	
				84	Analyser OFF		39
				30	Useful mod.		12
				20	AF meas.	6	13
				10	Ext.Mod.-Gen.OFF		38 EXT.
				87	Strobe		
55 -	J	T	- BANDWIDTH	61	Progr. lamps Clear		45,46,54, 55
				90	- bandwidth lamp	55 -	
				68	- δf		
				13	} see + bandwidth		
				64			
				72			
				47			
				15			
				02			
				14			
				84			
				30			
				20			
				10			
				87			

Button (Fig. 2-1)	ASCII character	Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
54 20 dB	J S	SENSITIVITY 20 dB	61	Progr. lamps Clear		45,46,54, 55
			63	Sensitivity test 20 dB	54 20 dB	
			69	Recall		
			64	Progr. selector 1		
			13	Modulation OFF		
			12	Modulation ON/OFF	42	
			72	A-AF		
			47	A-Mod.	3 kHz, rad or %	3 V
			15	RF level OFF		
			02	AF count OFF	2 MOD.-GEN.	
			14	RF level ON/OFF	43	
			84	Analyser OFF		39
			30	Useful mod.		12
			20	AF meas.	6	13
			10	Ext.Mod.-Gen.OFF		38 EXT.
			87	Strobe		
54 12 dB	0 S	SENSITIVITY 12 dB	61	Progr. lamps Clear		45,46,54, 55
			62	Sensitivity test 12 dB	54 12 dB	
			65	Progr. selector 2		
			66	Zero setting		
			13	see sensitivity test 20 dB		
			12			
			72			
			47			
			15			
			02			
			14			
			84			
			30			
			20			
			10			
			87			
46 ↑	N T	SQUELCH ↑	61	Progr. lamps Clear		45,46,54, 55
			89	Squelch ↑ - lamp	46 ↑	
			70	Print AF Ext.		
			33	Squelch AM		
			64	Progr. selector 1		
			13	see sensitivity test 20 dB		
			12			
			72			
			47			
			15			
			02			
			14			
			84			
			30			
			20			
			10			
			87			

Button (Fig. 2-1)	ASCII character	Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
46 ↓	B S	SQUELCH ↓	61	Progr. lamps Clear		45,46,54, 55
			88	Squelch ↓ - lamp	46 ↓	
			71	Print-Var.		
			33	Squelch-AM		
			64	Progr. selector 1		
			13	} see sensitivity test 20 dB		
			12			
			72			
			47			
			15			
			02			
			14			
			84			
			30			
			20			
			10			
			87			
45	B P	S/N measurement	61	Progr. lamps Clear		45,46,54, 55
			49	S/N lamp	45	
			65	Progr. selector 2		
			67	Entry		
			28	Single-tuned filter OFF		10
			13	Modulation OFF		
			12	Modulation ON/OFF	42	
			43	AF count ON	2 RESULT	
			87	Strobe		
15 1 kHz	N Z	1-kHz variation	81	1-kHz var.	15 1 kHz	5; 15 100 kHz, 10 Hz
			93	A-var.		
15 100 kHz	L Z	100-kHz var.	80	100-kHz var.	15 100 kHz	5; 15 1 kHz, 10 Hz
			93	A-var.		
15 10 Hz	J Z	10-Hz varation	74	A-RF	15 10 Hz	5; 15 100 kHz, 1 kHz
			93	A-var.		
5 (left)	H Z	AF variation	72	A-AF	5 (left)	15; 5 centre, right
			93	A-var.		
5 (centre)	F Z	Mod. variation	82	A-mod.	5 (centre)	15; 5 (left, right)
			93	A-var.		

Button (Fig. 2-1)	ASCII character		Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
5 (right)	D	Z	dB variation	73	A-dB	5 (right)	15; 5 (left, centre)
				93	A-var.		
25	L	P	pos. variation	86	+ var.		
25	A	\	neg. variation	85	- var.		
13 (above)	@	Y	Mod. meas. range I	16	Mod. meas. range I	13 (above)	13 (below)
13 (below)	A	Y	Mod. meas. range II	17	Mod. meas. range II	13 (below)	13 (above)
	B	Y	MOD. XO.01 OFF	30	Spurious mod. OFF Useful mod. ON		12
	C	Y	MOD. XO.01 OFF	30	Spurious mod. OFF Useful mod. ON		
12				31	Useful/spurious mod. ON/OFF	12	
	E	Y	CCITT-FILTER ON	26	CCITT-filter ON	11	
	F	Y	CCITT-FILTER OFF	26	CCITT-filter ON		11
11				25	CCITT-filter ON/OFF		
10 1 kHz	H	Q	DISTORTION 1 kHz	28	1 kHz ON, Polf. OFF	10 1 kHz	10 300 Hz
				27	Polfilter ON		
				68	-δf		
				65	Progr. selector 2		
				87	Strobe		
10 OFF	N	Q	DISTORTION OFF	28	Polfilter OFF		10
				69	Recall		
				65	Progr. selector 2		
				87	Strobe		
10 300 Hz	J	Q	DISTORTION 300 Hz	34	300 Hz ON	10 300 Hz	10 1 kHz
				27	Polfilter ON		
				68	- δf		
				65	Progr. selector 2		
				87	Strobe		
	M	←	PRINT AF	70	Print AF		
				87	Strobe		
	O	←	PRINT VARIATION	71	Print Var.		
				87	Strobe		
	K	X	PRINT DC-EXT.	74	AF-RF		
				64	Progr. selector 1		
				87	Strobe		
	M	X	PRINT RF level	73	A-dB		
				64	Progr. selector 1		
				87	Strobe		

Button (Fig. 2-1)	ASCII character	Function	Decimal value	ROM contents meaning	Illuminated button or display (see Fig. 2-1) ON	OFF
	O X	PRINT MOD./AF level	72 64 87	A-AF Progr. selector 1 Strobe		
	A W	PRINT RF	65 64 87	Progr. selector 2 Progr. selector 1 Strobe		

Table 4-2 ASCII 7-bit code and characters used for programming

Data lines D6 D5 D4 / D3 D2 D1 D0	Row \ Column	0	1	2	3	4	5
		H H H	H H L	H L H	H L L	L H H	L H L
H H H H	0	0	16	32 SP 3 mV	48 0 0	64 @	80 P
H H H L	1	1	17	33 ! 10 mV	49 1 1	65 A	81 Q
H H L H	2	2	18	34 " 30 mV	50 2 2	66 B	82 R
H H L L	3	3	19	35 # 100 mV	51 3 3	67 C	83 S
H L H H	4	4 SDC	20 DCL	36 $ 300 mV	52 4 4	68 D	84 T
H L H L	5	5	21	37 % 1 V	53 5 5	69 E	85 U
H L L H	6	6	22	38 & 3 V	54 6 6	70 F	86 V
H L L L	7	7	23	39 ' 10 V	55 7 7	71 G	87 W
L H H H	8	8	24	40 (	56 8 8	72 H	88 X
L H H L	9	9	25	41)	57 9 9	73 I	89 Y
L H L H	10	10	26	42 *	58 :	74 J	90 Z
L H L L	11	11	27	43 +	59 ;	75 K	91 [
L L H H	12	12	28	44 ,	60 <	76 L	92 \
L L H L	13	13 CR	29	45 -	61 =	77 M	93]
L L L H	14	14	30	46 .	62 >	78 N	94 ↑
L L L L	15	15	31	47 /	63 ? UNLISTEN	79 O	95 ← UNTALK
		Decimal value Information	Decimal value Information	Decimal value Character Information	Decimal value Character Information	Decimal value Character	Decimal value Character Information
		Addressed commands	Universal commands	Listener addresses		Talker addresses	

Table 5-1 Table for function control Y3

Function	Contact	Set (H) with button	Erase (L) with button	Illuminated button (with H)
FM modulation	32.2	RECEIVER 57 u. FM 37	XMITTER 58	FM 37
φM modulation	32.B	RECEIVER 57 u. φM 37	XMITTER 58	φM 37
AM modulation	31.N	RECEIVER 57 u. AM 37	XMITTER 58	AM 37
Int. mod. generator	31.12	MOD.-GEN.INT. 38	MOD.-GEN.EXT.38	MOD.-GEN.INT. 38
Ext. mod. generator	32.J	MOD.-GEN.EXT. 38	MOD.-GEN.INT.38	MOD.-GEN.EXT. 38
Modulation ON/OFF	31.U	MODULATION 42		MODULATION 42
RF level ON/OFF	32.4	RF LEVEL 43		RF LEVEL 43
Mod. meas. range I/II	32.17	XMITTER 58 and MOD. 13 (5 kHz/2 rad/30%)	20 kHz/5 rad/ 100%)	
Mod. AF meas.	31.24	XMITTER 58	RECEIVER 57	MOD. 13 or AF LEVEL 6
FM measurement	31.B	XMITTER 58 and FM 36	RECEIVER 57	FM 36
φM measurement	31.C	XMITTER 58 and M 36	RECEIVER 57	φM 36
AM measurement	31.L	XMITTER 58 and AM 36	RECEIVER 57	AM 36
Mod. indication control	31.Y	MODULATION (on) 42	RECEIVER 57 and CLEAR 37	Display 3
			or MODULATION (off) 42	
		or MOD.-GEN.INT. 38	XMITTER 58 and MOD.-GEN.OFF 38	
Useful/spur. mod. measurement	31.B	XMITTER 58 and XO.01 12		XO.01 12
1 kHz/300 Hz distortion	31.18	1 kHz 10	300 Hz 10	1 kHz or 300 Hz 10
AM EXT.	31.11	AM EXT. 30	OFF 33	AM EXT. 30
VAR. DC	32.7	VAR. DC 34	OFF 33	VAR. DC 34
FM EXT.	31.M	FM EXT. 31	OFF 33	FM EXT. 31
FM DC	32.H	FM DC 32	OFF 33	FM DC 32
Xmitter ON/OFF	32.8	XMITTER 58 or DUPLEX	RECEIVER 57	9
AF counter ON/OFF	32.$\overline{F}$	MOD.-GEN.EXT. 38 or SQUELCH 46 or SN 45 or BANDWIDTH 55 or DISTORTION 10	MOD.-GEN.INT.38 or RECEIVER 57	Display 2 H ≙ RESULT L ≙ MOD.-GEN.

Function	Contact	Set (H) with button	Erase (L) with button	Illuminated button (with H)
RF counter ON/OFF	32.26	XMITTER 58	RECEIVER 57 or DUPLEX 56	Display 1 H ≙ EXTERN L ≙ INTERN
Receiver test	31.6	RECEIVER 57	XMITTER 58 or DUPLEX 56	RECEIVER 57
Transmitter test	31.1	XMITTER 58	RECEIVER 57 or DUPLEX 56	XMITTER 58
+ bandwidth	31.E	+ BANDWIDTH 55	OFF 44	+ 55
- bandwidth	31.13	- BANDWIDTH 55	OFF 44	- 55
20 dB sensitivity	32.U	SENSITIVITY 20 dB 54	OFF 44	20 dB 54
12 dB sensitivity	31.R	SENSITIVITY 12 dB 54	OFF 44	12 dB 54
↑ Squelch	32.K	SQUELCH ↑ 46	OFF 44	↑ 46
↓ Squelch	32.9	SQUELCH ↓ 46	OFF 44	↓ 46
Self check	32.5	CHECK 41	OFF 44	CHECK 41
FM indication	31.T	MOD.INT. FM 37	XMITTER 58	kHz } Display 3
φM indication	31.16	MOD.INT. φM 37	XMITTER 58	rad } Display 3
AM indication	31.15	MOD.INT. AM 37	XMITTER 58	% } Display 3
AF level indication	31.5	XMITTER 58	RECEIVER 57	V } Display 3

Table 5-2 Initial addresses of input buttons and programming signals

Button (Fig. 2-1)	ASCII-character	Function	Binary address	Decimal address
5 (left)	H Z	AF var.	0 I 0 I I 0 0 0	88
5 (centre)	F Z	Mod. var.	0 I 0 I 0 I I 0	86
5 (right)	D Z	dB var.	0 I 0 I 0 I 0 0	84
10 1 kHz	H Q	Distortion 1 kHz	I I I 0 I 0 0 0	232
10 300 Hz	J Q	Distortion 300 Hz	I I I 0 I 0 I 0	238
10 OFF	N Q	Distortion OFF	I I I 0 I I I 0	234
11		CCITT filter ON/OFF	0 I I 0 0 I I I	103
	E Y	CCITT filter ON	0 I I 0 0 I 0 I	101
	F Y	CCITT filter OFF	0 I I 0 0 I I 0	102
12		Mod. X0.01 ON/OFF	0 I I 0 0 I 0 0	100
	C Y	Mod. X0.01 ON	0 I I 0 0 0 I 0	98
	B Y	Mod. X0.01 OFF	0 I I 0 0 0 I I	99
13 (above)	ⓐ Y	Mod. meas. range I	0 I I 0 0 0 0 0	96
13 (below)	A Y	Mod. meas. range II	0 I I 0 0 0 0 I	97
16 RF	ⓐ ←	MHz-RF	0 0 0 0 0 0 0 0	0
16 AF	J ↑	kHz-AF	0 0 0 I I 0 0 I	25
17 FM	A ↑	kHz-FM	0 0 0 I 0 0 0 I	17
17 φM	E ↑	rad-φM	0 0 0 I 0 I 0 I	21
17 AM	I ←	%-AM	0 0 0 0 I 0 0 I	9
18 AF	F ←	V-AF	0 0 0 0 0 I I 0	6
18 RF	B ←	dB-RF	0 0 0 0 0 0 I 0	2
21	D ←	kHz-δF	0 0 0 0 0 I 0 0	4
23 +δf	O [	+δf	0 I 0 0 I I I I	79
23 -δf	B Z	-δf	0 I 0 I 0 0 I 0	82
25	L P	- variation	0 0 I I 0 0 0 I	49
25	A \	+ variation	I I I I I I 0 0	252
30	L [	AM-EXT.	0 I 0 0 I I 0 0	76
31	M [	FM-EXT.	0 I 0 0 I I 0 I	77
32	K [	FM-DC	0 I 0 0 I 0 I I	75
33	N [	OFF	0 I 0 0 I I I 0	78
34	J [	VAR-DC	0 I 0 0 I 0 I 0	74
36 FM	H Y	FM- } Mod. measurement	0 I I 0 I 0 0 0	104
36 φM	K Y	φM- } Mod. measurement	0 I I 0 I 0 I I	107
36 AM	N Y	AM- } Mod. measurement	0 I I 0 I I I 0	110
37 FM	G \	FM } Mod.-INT.	0 0 I I 0 I I I	55
37 φM	B \	φM } Mod.-INT.	0 0 I I 0 0 I 0	50
37 AM	L \	AM } Mod.-INT.	0 0 I I I I 0 0	60
37 CLEAR	C X	Clear } Mod.-INT.	0 I I I 0 0 I I	115

Button (Fig. 2-1)	ASCII-character	Function	Binary address	Decimal address
38 INT.	L ↑	MOD.-GEN. INT.	0 0 0 I I I 0 0	28
38 EXT.	E]	MOD.-GEN. EXT.	0 0 I 0 0 I 0 I	37
38 OFF	F X	MOD.-GEN. OFF	0 I I I 0 I I 0	118
39		ANALYS. ON/OFF	I 0 0 0 0 I I 0	134
	E W	ANALYS. ON	I 0 0 0 0 I 0 I	133
	D W	ANALYS. OFF	I 0 0 0 0 I 0 0	132
40		-MOD.IND. ON/OFF	0 I I I 0 0 I 0	114
	A X	-MOD.IND. ON	0 I I I 0 0 0 I	113
	ⓐ X	-MOD.IND. OFF	0 I I I 0 0 0 0	112
41	M R	CHECK	I I 0 I I I 0 I	221
42		MODULATION ON/OFF	0 I 0 0 0 0 I 0	66
	A [	MODULATION ON	0 I 0 0 0 0 0 I	65
	ⓐ	MODULATION OFF	0 I 0 0 0 0 0 0	64
43		RF LEVEL ON/OFF	0 0 I 0 I I 0 0	44
	K]	RF LEVEL ON	0 0 I 0 I 0 I I	43
	J]	RF LEVEL OFF	0 0 0 0 I 0 I 0	42
44	ⓐ U	Test progr. OFF	I 0 I 0 0 0 0 0	160
45	B P	S/N	I I I I 0 0 I 0	242
46 ↑	N T	Squelch ↑	I 0 I I I I I 0	190
46 ↓	B S	Squelch ↓	I I 0 0 0 0 I 0	194
54 20 dB	J S	20-dB sensitivity	I I 0 0 I 0 I 0	202
54 12 dB	O S	12-dB sensitivity	I I 0 0 I I I I	207
55 +	F T	+ bandwidth	I 0 I I 0 I I 0	182
55 -	J T	- bandwidth	I 0 I I I 0 I 0	186
56	L V	Duplexer test	I 0 0 I I I 0 0	156
57	ⓐ U	Receiver test	I 0 I 0 0 0 0 0	160
58	J W	Transmitter test	I 0 0 0 I 0 I 0	139
	M ←	PRINT AF frequency	0 0 0 0 I I 0 I	13
	O ←	PRINT variation	0 0 0 0 I I I I	15
	K X	PRINT DC-Ext.	0 I I I I 0 I I	123
	M X	PRINT RF level	0 I I I I I 0 I	125
	O X	PRINT mod./AF level	0 I I I I I I I	127
	A W	PRINT RF frequency	I 0 0 0 0 0 0 I	129

Table 5-3 Contact occupation for connection between Control Unit and Indicator

BU18, ST18

.1	RF register strobe	.13	+5 V
.2	dB strobe	.14	AF count
.3	+7 V	.15	RF count
.4	AM strobe	.16	RF level ON/OFF
.5	FM strobe	.17	chassis (0 V)
.6	Mod.-indication control	.18	D ⎫
.7	RF indication strobe	.19	C ⎬ Data bus
.8	FM ⎫	.20	B ⎭
.9	φM ⎬ indication	.21	A
.10	AM ⎭	.22	A
.11	V-	.23	B ⎫ Address bus
.12	AF indication strobe	.24	C ⎭

BU19, ST19

.1	A ⎫	.26	C ⎫
.2	B ⎬ Variation address	.27	B ⎬
.3	C ⎭	.28	A ⎭
.4	B ⎫	.29	G ⎫
.5	A ⎬ Manual entry	.30	F ⎬ Manual initial address
.6	Strobe ⎭ AF level range	.31	E ⎬
.7		.32	D ⎬
.8	C ⎭	.33	H ⎭
.9	Doubler ON/OFF	.34	Modulation meas. range I/II
.10		.35	300 Hz/1 kHz
.11	6-dB switchover	.36	
.12		.37	+15 V
.13	Single-tuned filter	.38	-15 V
.14		.39	
.15	+7 V	.40	DC RF level, 0 - 1 mA
.16	-10 V	.41	DC power meter
.17	-10 V	.42	NIII ⎫
.18	Chassis	.43	NI ⎬ Meas. range of power meter
.19	Chassis	.44	NII ⎭
.20	+5 V	.45	
.21	+5 V	.46	CCITT filter
.22	C ⎫	.47	Useful/spurious modulation
.23	B ⎬ AF level range	.48	
.24	A ⎭	.49	Mod./AF meas.
.25	A ⎭	.50	DC AF level, 0 - 1 mA

MP MASTER
MA23829